JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE

State of Pennsylvania,

AND

AMERICAN REPERTORY.

OCTOBER, 1842.

Civil Engineering.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Remarks on Reaction Water Wheels used in the United States; and on the Turbine of M. Fourneyron, an Hydraulic Motor, recently used with the greatest success on the continent of Europe. By ELLWOOD MORRIS, Civil Engineer.

By way of preface, following a similar classification to that indicated by the celebrated Smeaton, in his experiments on water wheels, we may, with propriety, rank these hydraulic motors under three general heads, to which, *directly or indirectly*, they may all be referred. Viz:

1*st class.* *Wheels actuated by pressure*, such as overshot wheels.
2*nd class.* *Wheels actuated by impulse*, such as undershot wheels.
3*rd class.* *Wheels actuated by impulse and pressure combined*, such as breast wheels.

It is evident, however, that this last class may be made to vanish into either of the others, according as pressure or impulse is mainly applied; and in perfect strictness, all water wheels, may be brought under the *third class*, for even overshot wheels are actuated in part, though it be but a small part, by the impulse of the water issuing into the buckets; whilst undershot wheels, though mainly impelled by impulse, owe a small part of their motion to pressure, for the water striking the floats in a thin sheet, follows and rises against them, so as to bring a certain pressure into play, more especially if it be discharged against

the wheel a little above its bottom, and then confined by a sweep, as is often done.

Yet as in making almost any general classification of machines, we are under the necessity of ranking them according to their *prevailing characteristics*, the above nomenclature is perhaps as expressive as any we could adopt for general purposes, and certainly has a basis in well understood practical distinctions.

Each of these classes has a particular ratio of effect, produced by a given power expended; this ratio is usually expressed by a decimal co-efficient, assuming the power to be unity; and is here regarded as applying to the total fall of the water, or to the *head and fall*, as it is usually termed.

Thus in wheels of the

1st class, the co-efficient of effect	is usually	from		0.700 to 0.800.
2nd class,	do.	do.	do.	0.350 to 0.400
3rd class,	do.	do.	do.	0.500 to 0.600

The *co-efficient of effect* of wheels of the first class is assumed for our present purposes at 0.700 to 0.800, in consequence of the able experiments of the Franklin Institute having shown that under favorable circumstances, even *eighty-four per cent.* of the power expended may be realized by overshot wheels; whilst Smeaton's experiments developed a ratio of power and effect of 3 : 2, giving 0.666 for the co-efficient of effect.

The same co-efficient for wheels of the second class, is deduced from that of the first, by the comparative ratio shown by Smeaton to subsist between overshot and undershot wheels, viz: that the latter, in situations adapted to their use, realized but *one-half* of the useful effect attained by the employment of the former at proper sites.

This co-efficient has been collaterally verified, in experiments made by French officers upon *wheels of impulse* at Toulouse, of the species we call *tub wheels*, of which the ratio of effect to power proved to be 0.342 to 1.

We shall hereafter see that *reaction water wheels*, which we regard as *wheels of impulse*, or as belonging to the second class, had, in one experiment, also a co-efficient of 0.400; that in another where the precise ratio could not be determined *directly*, it was *indirectly* found, by showing that the wheel under trial returned an available effect but *half as great* as a wheel of the first class, and that, therefore, as a necessary consequence, its co-efficient of effect must have approximated in that case also to 0.400; and it will be further shown, that, tried upon a low fall for several years, reaction wheels proved to be inferior in economy of water, to common breast wheels, whence the conclu-

sion is inevitable, that their co-efficient in this case *must have been* less than 0.500.

On the other hand, the *turbine* of M. Fourneyron, has been proved by the able experiments of Capt. Morin, to have a co-efficient of 0.700 to 0.780, or to realize a useful effect, of about three-fourths of the power expended; which is very nearly coincident with that which we have assigned to the *wheels of pressure*, or those of the first class, amongst which we place the *turbine*.

We will finally mention the position in the scale of effect, which it seems to the writer, may be fairly assigned to the various water wheels *in common use*.

1st class. *Wheels of pressure.*—Overshot wheels, pitch-back wheels and turbines; *co-efficient* = 0.700 to 0.800.

2nd class. *Wheels of impulse.*—Undershot wheels, tub wheels, flutter wheels, and reaction wheels; *co-efficient* = 0.350 to 0.400.

3rd class. *Wheels of pressure and impulse combined.*—Breast wheels; *co-efficient* = 0.500 to 0.600, but upon low falls where they are commonly employed, rarely exceeding 0.500.*

As it is not by any means our purpose however, to enter into a general discussion of the subject of water wheels—which has been already confided, by the Franklin Institute, to a very able committee, engaged in elaborating, and publishing, the valuable results that flow from a prolonged series of experiments, made by them some years since—and having already said enough upon the general question, to enable an idea to be formed of the comparative value of the *reaction* and *turbine* wheels, which are the particular objects of this paper, we will now confine ourselves more strictly to these subjects.

* At Fairmount Waterworks, for example, about thirty gallons expended upon the breast wheels with eight feet fall, raise one gallon ninety-six feet into the reservoirs. *To find the co-efficient?*

$$\frac{30\times 8}{1\times 96}=2\tfrac{1}{2}$$ whole power expended for 1 raised to the same height.

Deduct power lost by the application to a breast wheel, say *one half*	$=1\frac{1}{2}$
	$1\frac{1}{2}$
Deduct friction of pumps, say 20 per cent.,	$=\frac{1}{2}$
Reduced effect thereof	$=1$

From this rough estimate it appears, that if the friction of the pumps, &c., is 20 per cent., then these breast wheels realize an effect of $1\frac{1}{2}$, for a power expended of $2\frac{1}{2}$, or have a co-efficient of 0.500, which confirms what we have above stated upon this point.

Of Reaction Water Wheels.

Reaction water wheels are a very numerous family, of which the well known hydraulic motor, called Barker's mill, is the parent; those used in various parts of the United States, have usually vertical axes of rotation, and curved buckets, or vanes, against which the impulsive force of the water, (spouting from within the wheel by ajutages of which the curved vanes form the sides) *acts indirectly*, or rather *reacts*, thus producing (in reference to the effluent water) a *backward rotary motion*, similar in character and effect, to the *forward rotary motion*, produced by direct impulse in the case of undershot wheels.

It is only, comparatively speaking, quite recently that reaction water wheels, of the form at present in use in the United States, have occupied a prominent position before the public.

In 1830, Calvin Wing took out a patent for a *reaction water wheel*,* with curved vanes of the figure shown in the annexed horizontal section, in which A is the place of the vertical shaft, C C the curved vanes or buckets, *e d* lap of the vanes; the width of the orifice at *e* being always *less* than at *d*.

In this species of wheel the water has free entrance to the circular space within, and spouting out by the openings between the curved vanes, impels the wheel around in a backward direction, by its *reaction* against the vanes, in issuing, *with velocity*, from within the wheel.

Fig. 1.

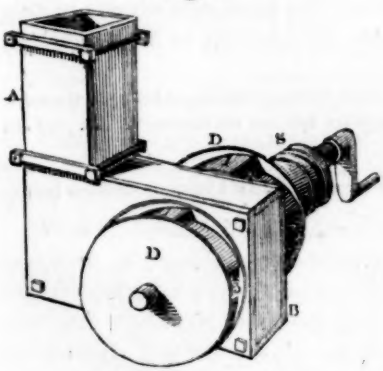


Fig. 2.

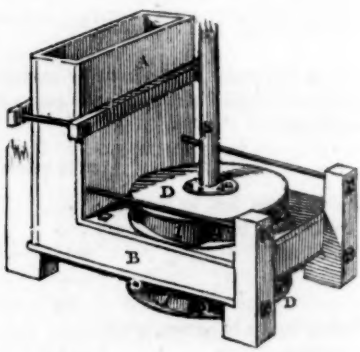


Fig. 1 shows *a double reacting wheel* placed on a horizontal shaft S, the penstock being marked A, the cistern or feeding reservoir

* See specification in the Journal of the Franklin Institute, vol. vii, p. 86, some of the illustrations of which are reprinted above.

B, and the two water wheels respectively D and D, which revolve in vertical planes as indicated in the cut.

Fig. 2 is *a double reacting wheel* on a vertical shaft, A being the penstock, B the cistern or feeding box, and D, D, the water wheels revolving horizontally.

Mr. Wing in his specification lays considerable stress on the necessity of causing the vanes to lap by each other, in the ratio of one and a half inch lap, for each inch of the width of the ajutage, or shortest horizontal distance between any two adjacent vanes; he proposed also to employ his wheels either upon vertical or horizontal axes, and they have been made and used in both ways, as shown in the cuts.

Wing's patent is the earliest one referring to this general form of *reaction water wheel*, which the writer, in a brief search, has been able to find on record; but he has good reason to believe that reaction wheels remarkably similar, if not exactly the same in principle and outline, were tried upon the Brandywine, and abandoned, some years previous to 1830; and that therefore the invention had been antecedently made, and probably patented before.

Since the date of Wing's patent, many others have been taken out for reaction water wheels, but most of these subsequent inventors, have evinced by their productions, a perfectly accurate knowledge of the wheel patented by Wing, for it is a very difficult matter to distinguish them from it, or from each other, and this striking resemblance in general form, becomes identity as to *principle* involved; and with equal accuracy of workmanship, it would seem to be impossible that they can differ more in effect, than would be the case in as many undershot wheels, built by different millwrights, each according to his own fancy.

This view is confirmed by experiments upon two of the most dissimilar, (hereafter cited,) which indicate, that the *co-efficient of effect* in both cases was about 0.400—in fact coming under the general category of *wheels of impulse*, the writer believes that *reaction wheels* will be found, without exception, to approximate as closely in their results, to the co-efficient of this class, as can or ought to be expected, in practical affairs of this nature.

In the American Philosophical Transactions, 1793, William Waring, a mathematician of celebrity, investigated, analytically, the subject of reaction water wheels, in examining the merits of Rumsey's improvement of Barker's Mill, and the conclusion to which he came, after a train of reasoning based upon scientific principles, was, that they were *merely equal in effect to undershot wheels.*

And he came to the same conclusion from the following brief argument.

"*Action and reaction are equal.*" "But the undershot wheel is propelled by the *action*, and (Barker's Mill) by the *reaction* of the same agent, or momentum. *Therefore their mechanical effects must be equal.*"

This conclusion, which is strictly accordant with that to which all the information upon this point tends, which it has been in the power of the writer to collect; was further enforced by Mr. Waring, with reference to the elementary laws of forces, as laid down in Newton's Principia; and his article upon this subject, to which we have allusion, will be found interesting by such as feel disposed further to investigate this important question.

In the year 1833, the writer's attention was closely drawn to the matter in hand, in consequence of having been called upon by a friend to examine for him a *reaction water wheel*, in the patent right for which he had been invited to take an interest, and which had just been put into use.

In consequence of this application the writer visited a grist mill, where a *breast wheel* had just been removed by the proprietor, to make room for this reaction wheel, which, like most of the others, resembled *very closely* that of Calvin Wing.

At this grist mill the writer made the following experiment, after it had been put in action by the reaction wheel; and though this trial could not, under the existing circumstances, be made as accurate in its character as might have been desired; still it was sufficient for the purpose of ascertaining *approximately* the useful effect derived, as compared with the work of overshot and undershot wheels, in common use; which comparison was the best test of the probable value of the patent right, as it could only be valuable, by superseding the common wheels, which the inventor (as is usual) was perfectly confident that his *reaction wheel* would speedily do.

Experiment on a Reaction Water Wheel applied to a Grist Mill, February 4, 1833.

This mill was double geared, in the usual manner, with beveled gearing, the first motion being given from the vertical shaft of the reaction wheel, by a beveled wheel of thirty-five teeth, mashing into another of forty teeth, placed at one end of a lying shaft leading into the mill, on the other end of which was,

The master cog wheel, working into
The wallower, working into
The counter cog wheel, working into
The trundle head, carrying the millstone.

The millstones were four feet in diameter, in very bad order, out of face, and the bush loose.

Top of the reaction wheel twelve inches under the water in the tail race, working under four feet head and fall, being the whole difference between the upper and lower level; ground *very badly* three and a quarter bushels of rye, by measurement, in an hour; expense of water equal to the whole quantity passing over a wasteboard set up for the purpose in the penstock, and having a clear fall below.

Length of wasteboard eighty-five inches, depth of the edge beneath surface of water above it, ten inches; quantity of water discharged, calculated by the well known formula of Du Buat, as verified by Dr. Robison, and long employed by Engineers as an accurate mode of determining the flow of water over a wasteboard,=1200 cubic feet per minute.

During the above trial the bolting apparatus, consisting of a single reel and cloth, was in gear, but there was neither conveyer, hopper-boy, nor elevator in the mill.

In fine, the conclusion drawn by the writer at the time, from this experiment, (though necessarily approximative only) was, that if it were assumed, that with every thing in good order, such a wheel in a completely fitted mill, could grind and dress three bushels of wheat per hour on a four and a half feet stone, by the use of 1200 cubic feet of water per minute, with four feet head and fall, *it would be a conclusion as favorable to the reaction wheel tried, as could possibly be admitted from this experiment.*

Now 1200 cubic feet multiplied by four feet head and fall, and divided by three bushels of wheat=1600 *cubic feet of water falling one foot per minute for sixty minutes, required to grind and dress one bushel of wheat by this reaction wheel.**

To compare, therefore, the work of this wheel with that of others, it was only necessary to ascertain the same factor for an overshot wheel, the relation of which, to undershot and breast wheels, having been already determined with practical accuracy by Smeaton; to as-

* This amount of water required, seeming considerably larger than would have been needed by a breast wheel, to do the same work, induced the writer, upon the spot, to declare an opinion unfavourable to the economy of the reaction wheel under trial, in consuming water; which opinion was, of course, but ill received by the sanguine patentee.

And the proprietor of the mill also, where it was erected, was so well pleased with his new wheel, as to be evidently indisposed to hearken to any suggestions adverse to it; consequently the only course was to leave these parties to the action of time and experience, before which no bad machine can long stand; and the result has been that this reaction wheel was long since discarded, by that same proprietor, as incapable of doing the requisite amount of work; whilst the then repudiated breast wheel has been restored to favour and to duty.

certain this, therefore, was at once to secure the means of contrasting this reaction wheel, with either of the three.

For this purpose the writer, at first, resorted to books of the highest authority in this branch of mechanics, but amongst them he found great and irreconcilable discrepancies, as to the quantity of water falling one foot per minute (upon an overshot wheel) for sixty minutes, which was necessary to grind and dress a bushel of wheat in one hour; the variation between these authorities, in reference to the amount required, ranging from 300 to 1344 cubic feet per minute!

Under these circumstances, the writer resolved to ascertain for himself, the actual quantity consumed in practice here, upon overshot wheels; for this purpose he selected and examined *three excellent overshot mills*, containing all the modern improvements, and found that, calculating by the whole head and fall, they required when running at their common working pace, and with every thing in the usual order, 788 *cubic feet of water falling one foot each minute, to grind and dress one bushel of wheat in an hour.**

Consequently by the known ratio subsisting between overshot and undershot wheels, the latter in doing the same work would use 1576 cubic feet of water in the same time.

Hence as we have seen that the reaction wheel required 1600 cubic feet to do the same work, and knowing also the co-efficient of effect for undershot wheels, we have the following proportion.

$$1600 : 1576 : : 0.400 : 0.394$$

Consequently the co-efficient of effect in reaction wheels, as inferred from this experiment, assuming the co-efficient of undershot wheels to be 0.400, is 0.394, or nearly coincident therewith.

A similar fate to that which befell this reaction water wheel, the subject of the foregoing experiment, (as stated in the preceding note) has likewise happened to other wheels of the same species, as we shall now mention; and will probably also befall, the greater part of those yet in use, so soon as the merits of the French *turbine*—that admirable hydraulic motor, which possesses all the *advantages*, and none of the *disadvantages*, of reaction wheels—shall become better known, and be appreciated, as they will be, when fairly understood.

The American experience which has now been had with the water

* Now if we suppose that under the usual practical circumstances, we can only realize a force equal to lifting two-thirds of the power applied to an overshot wheel, we have then $788 \times \frac{2}{3} = 525$ cubic feet. Then an available work of $525 \times 62\frac{1}{2} = 32{,}812$ lbs. raised one foot high per minute, *or one horse power of Boulton and Watt's steam standard, will grind and drsss one bushel of wheat per hour;* which is easily remembered, and is undoubtedly *a safe practical rule*, erring probably in excess, rather than otherwise, when the mill is well constructed and properly managed.

wheels of impulse, commonly called reaction wheels; where fair comparative trials have been made with them against others, may, in a great measure, be gathered from the following history of the proceedings of a distinguished and intelligent manufacturer, (the owner of several large mills) whose name the writer does not feel at liberty to mention, but whose letters upon the subject of his practice with reaction water wheels, have been placed in the writer's hands by a friend, to whom they were addressed in answer to inquiries concerning the efficiency of these motors.

The letters of this gentleman—who had used a number of reaction water wheels in his mills, who possessed the patent right of one of the best of them, and who was, therefore, pecuniarily interested in their success;—breathe a most admirable spirit of candor and intelligence, and seem to be decisive upon the point, *that reaction water wheels are not economical in the use of water;* though he finally adheres to the opinion, (correct beyond any doubt) that they are superior to ordinary breast wheels, when flooded by backwater.

May 14*th*, 1833.—This intelligent manufacturer states,—that at one of his mill sites, where the head and fall is five and a half feet, *and very liable to backwater*, after trying several reaction wheels, and being well satisfied with them, he was about to take out a breast wheel of eighteen feet long and nine feet diameter, with straight floats, and substitute a reaction wheel of cast iron. The whole tenor of this letter is favorable to reaction wheels, though he says with candor, that he is unwilling to express the opinion that where there is no backwater the reaction wheels will do more work with the same amount of water than a good breast wheel can perform.

July 20*th*, 1833.—The same gentleman says he fears that he was too sanguine in his former letter—that three of the new reaction wheels put in action at one of his mills, which were expected to carry 2000 spindles, have proved to be able to carry but 1200—that these wheels consume a great deal of water, and yield but little power in return—that he must get the patentee to see if any thing is wrong—that if they do not perform better he must return to the breast wheel, and use them only as auxiliaries, and finally, "*that reacting wheels are only valuable in backwater, and where there can be no possible want of water to supply them.*"

August 17*th*, 1835.—The same gentleman, after nearly four years experience in the use of reaction water wheels of the most approved pattern, states, as a summary of his practice, that:

"In backwater they are unsurpassed by any other wheel within my knowledge, for the simple reason that they will run under such head as remains, and running horizontally, and not lifting from the water,

expend no power, as float wheels do, in rising out of backwater. But the power of these wheels depends, like others, upon the head under which they act, and when that head is lessened by backwater, their power is proportionally diminished. I have been each year *supplying the place of these wheels* (the reaction) *with the straight float* (breast wheel) and am now putting in two of the *latter* at one of my mills. The reason is that *the reaction wheels used the water to too great waste, and were continually out of order.* I own the patent right for a reaction wheel,* and have a half dozen on hand for which I have no use. I have also one of Wing's out of use, and of no value to me."

The above recital of the experience of an intelligent, practical man, in the use of these wheels at a site *affected by backwater*, and, therefore, the better suited to develope their peculiar advantages, is, in consequence of his being personally interested in their success, worthy of particular notice, as clearly displaying, firstly, the approval of reaction water wheels; secondly, their trial and doubts of their utility, and finally, their repudiation; which—as though a fondness for these motors was a disease with fixed symptoms and a crisis—are the same stages of opinion that others, who tried them, have passed through in several cases known to the writer; where breast wheels were eagerly discarded for reaction wheels, which, on full and fair trial, were still more eagerly repudiated, to reinstate, the formerly rejected breast wheels.

From a letter addressed by another manufacturer, (located in a different quarter of the country) to the same gentleman whose kindness has supplied us with the above, the following is extracted.

July 14th, 1836.—"The patentees of a reaction wheel offered to put one in for me, that should drive a certain number of throstle spindles, and other machinery *named*, with a certain quantity of water, *also named*, for a stipulated price; and if the wheel when finished would not drive all the machinery mentioned, they should have nothing for putting it in. I accepted their offer, and we entered into a written agreement; they put in the wheel, but they could not make it drive all the machinery they engaged it should, although they used *more water* than was agreed upon. This wheel is geared into the same upright shaft with the breast wheel I had previously put in, which afforded a fair opportunity of testing the power of the wheels; I therefore threw the breast wheel out of gear, and put as much machinery on the *reaction wheel* as it would drive at speed, *and measured the water it was using;* I then put the *breast wheel* in gear, drew water

* This wheel was regarded as one of the very best of the species, all of which are remarkably similar, as we have before stated.

enough on it to make it drive the same machinery, at the same speed it was driven by the reaction wheel, *and measured the water as before*, the difference was considerably in favour of the breast wheel certainly, and if the measurement of the water was correct, *it was quite* 20 *per cent.*"

This *direct* comparison of the work of reaction and breast wheels, made upon a large scale, and under precisely the same circumstances, appears to be absolutely decisive that the former are inferior to the latter, as an hydraulic motor, when the question of *backwater* is left out of view.

Now the ratio of power to effect which commonly obtains in breast wheels, as employed in this country, is about 10 to 5, or their co-efficient of effect may be taken at 0.500; hence if the breast wheel requires, as stated above, 20 per cent. less water to produce the same effect than the reaction wheel did, we have the following proportion to find the co-efficient of the latter, viz:

$$12\tfrac{1}{2} : 10 : : 0.500 : 0.400.$$

From trial by this manufacturer then, it seems that the co-efficient of effect of reaction water wheels is about 0.400; by our own experiment its value must have been near 0.400, by the experience of the other manufacturer cited, it is clear that it must have been considerably less with his reaction wheels than 0.500, and, finally, by Mr. Waring's investigation, that it was only equal to the undershot co-efficient.

In consequence of all this, we are induced from the information at present in possession, and from some personal observations, to form the opinion, that at least, where they are actuated by a clear fall of water unimpeded below, *the ratio of effect to power in reaction water wheels, is not higher than in good undershot wheels, under the same circumstances.*

If this conclusion is correct (and *if not*, we hope the contrary will be experimentally shown by some of the numerous readers of this journal, who are competent to such researches) it is truly surprising that proprietors of works driven by overshot wheels, with a fine fall, should ever, in any case, have resorted to the use of these *water consumers;* as has been done, to some extent, at the government works at Harper's Ferry, and at a few other points, known to the writer, where *overshot wheels* have been removed to make way for those of *reaction!* which it would appear from the above remarks, *consume twice as much water to produce a given effect, or as much as undershot wheels usually do.*

TO BE CONTINUED.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Cost of Transportation on Railroads. *By* C. ELLET, JR., *C. E.*

[CONTINUED FROM PAGE 147.]

On the Value of Gradients. In the preceding number I proposed a formula for the determination of the cost of transportation on railroads. I am aware that that expression is not in accordance with the opinion which now prevails in regard to the economy of railroad conveyance; and that there are many gentlemen of experience and reputation who are prepared to adopt a much lower estimate than mine. But, until some road can be adduced on which the experiment has been tried long enough to exhibit a result which can be received as a fair average, and which authorizes lower constants, I cannot consent to the reduction of the formula. In its present state it gives a measure below the actual performance on any road in the United States.

I am also aware that, in not presenting the average cost of freight in any particular number of cents per ton per mile; or in any particular sum per mile traveled by the locomotive engines, I have deviated from the popular and most approved methods of treating the subject. But I regard the aggregate cost per mile run as no guide whatever to the economy which characterizes the management of a railroad; and deem it an unauthorized assumption that because this sum is, in any instance, unusually low, the work is conducted with more than ordinary success. The fact, where it exists, can only be used to prove, if other circumstances remain the same, that the engines have taken smaller loads, and made a greater number of trips, and run more miles, than was absolutely necessary. In fact, if we admit, what cannot well be denied—that under similar circumstances, and with engines of the same class, the cost of locomotive power is proportional to the distance run—or that the cost of running one mile is not *diminished* by *increasing* the load, it follows as a consequence that, *cæteris paribus, the more economical the administration of a road, the greater will be the aggregate cost per mile run by the locomotive engines.*

Neither is the circumstance that the aggregate expenses of a line for one year divided by the number of tons conveyed, exhibits a low average per ton per mile, any test of good management. The fact, by itself, is more likely to prove that the tonnage was great than that the administration was judicious.

I shall now proceed to deduce from this general expression of the cost of freight, certain consequences of the utmost importance in the location and establishment of railroad lines, which I believe have hitherto been little, if at all, regarded.

What is the Value of Gradients? I mean by this question, how

much more is a railroad having gradients of thirty feet per mile worth than the same road with grades of forty feet per mile? Or, how much money would good economy authorize an engineer to expend, in the construction of his road, in order to reduce the limiting gradient any given amount?

I have seen various intricate and laborious solutions of questions which involve the loss of *time* and the consumption of *steam* in the ascent of gradients; but I have never yet met with any examination of this interesting and all important problem. The loss of *time*, in this country, is usually a matter of little consequence in the transportation of merchandize; and experience teaches that the cost of motive power is very nearly proportional to the distance traveled by the engine, and very little affected, within the limits which ordinarily occur in practice, by irregularities in the tractile power. It is no doubt true that if we were to make observations under extreme circumstances —as where the engines move on a perfect level, and where they frequently mount the steepest grades they can possibly ascend without loads—the cost of motive power per mile run, would be found to exhibit very considerable variations. The charges for fuel, as well as for repairs, would be materially increased by the increase of the acclivity of the grades. But we have no such extreme cases in practice; and the following investigation is based on the authorized assumption that the cost of running the locomotive engine and its tender, without other load, is proportional to the distance run, and independent of variations of the tractile force consequent on the ordinary irregularities of grade.

In the preceding number, the aggregate annual expenses of a line of railroad under good management were represented by this formula,

$$\frac{3\,N}{10}+\frac{14\,T}{1000}+500h, \qquad (A)$$

In which N is put for the number of miles traveled, during the year, by the locomotive engines, T the number of tons net carried one mile, and h for the length of the line.

This formula, it will be observed, expresses the cost of transportation without any express computation of the effect of the grades over which the tonnage is carried. Nevertheless, the result which it yields is not independent of the grades; for they enter into the value of N, and control the number of miles traveled by the engines. The variation of the maximum gradient will not cause a sensible variation of any item of the aggregate cost of transportation excepting that of the locomotive power.

Now, in deducing the changes in the cost of locomotive power consequent on changes of grade, I shall assume that the circumstances of the trade are such as will permit that the machine be always started

with a full train—that is to say, with the largest train which it is certain to control on the limiting grade. In many instances this assumption is not strictly in accordance with the facts; since it is frequently advisable —particularly where the grades are light, and the trade inconsiderable—to effect a portion of the transportation with imperfect loads. In such cases greater ascents might obviously be encountered without increasing the cost of carrying every train; and the effect of assuming that the trains are all full, when a portion of them is not full, will evidently be, to render the estimated increase of cost consequent on the gradient somewhat higher than it really is.

The formula is intended to fix *a limit* within which the actual value of the grade must always be found; and as it should be the object of every company to do their transportation with the least possible labour, and at the least possible cost, the number of miles actually traveled ought to approach very nearly the number corresponding with the assumption of full trains; and consequently, except in extreme cases, the estimate should not be much in excess. But if the situation and circumstances of the line be such as will preclude the probability of loading all the tonnage trains to the proper limit, some allowance may be made, in the application of the formula, for that portion of the trade which it does not embrace.

Now, if the limiting gradient of the road be changed, the number of miles traveled by the locomotive engines will also be changed. If the load be reduced one half by the introduction of any plane, the number of trips, and, consequently, the cost of locomotive power, will be very nearly doubled by the admission of that plane.

But the number of miles traveled by the engines in the course of a year, supposing them to convey full loads, and the transportation, accordingly, to be effected with the greatest possible economy of power, will be expressed by

$$\frac{2\,T'}{n} = N,$$

Where n is put for the average gross load in tons, up the limiting grade, and T' for the gross weight in tons carried in full trains one mile in the direction to which that gradient is opposed.

We know, from satisfactory experiments, that an inclination of twenty feet per mile, on a road in good adjustment, requires for its ascent a power nearly double; and one forty feet per mile a power treble, and one of sixty feet a power quadruple (or, for grades under eighty feet, very nearly in this proportion) that which is required to draw the same weight on a level. In other words, if W be the gross load an engine is capable of drawing with safety and certainty on a level road, and x the inclination, in feet per mile, of the gradient which limits the load, then

$$\frac{20}{20+x}\,W=n$$

will be the load, near enough for our object, with which it can mount the plane ascending x feet in a mile.

If we now designate by C the cost of running the engine with its tender only, one mile; by c the additional cost of motive power per mile, due to each ton gross added to the load—then $C+cn$ will be the whole cost of motive power per mile run. This sum may be written

$$C+c\frac{20\,W}{20+x},$$

by substituting for n its value expressed in terms of the grade and the power of the engine.

If we now multiply this sum by $2\,T'\,\frac{20+x}{20\,W}$, the number of miles that ought to be traveled by all the engines in the course of a year, we shall obtain for the whole annual expense of motive power

$$2\,T'\left(C\frac{20+x}{20\,W}+c\right),$$

and for the whole annual cost of maintaining the line and transmitting the trade which it receives

$$2\,T'\left(C\frac{20+x}{20\,W}+c\right)+\frac{14\,T}{1000}+500\,h; \qquad (B)$$

in which we have the aggregate cost of transportation, with the greatest attainable economy of power, cleared of the number of miles traveled by the engine, and expressed in terms of the particular grade which controls the cost of power.

In order to determine the sum which we might expend for the reduction of this limiting gradient, which is the problem under consideration, we must ascertain the value of this formula for different values of x, and take the difference between those values.

If we now suppose x to assume the new value x', the corresponding difference produced in the aggregrate annual expenses by the change of gradient, supposing still that the trains are full, will be

$$2\,C\frac{x'-x}{20\,W}T'. \qquad (C)$$

The increase of expenses is proportional to the increase of the sine of the angle of inclination of the gradient; and directly proportional to the gross tonnage which ascends the limiting grade, in full trains, and reciprocally as the power of the engine capable of running one mile at the assumed cost of locomotive power.

The value of gradients, or the expenses which they produce on railroad lines, will diminish, therefore, proportionally to the improvement in the power of the engines.

Let us now substitute for C its value—three-tenths of a dollar—and put $x'-x=1$; and we shall obtain

$$\frac{3\,T'}{100\,W} \qquad (D)$$

for the increase of the annual expenses of a road consequent on the addition of one foot per mile to the acclivity of the limiting slope.

It is not easy to assign the proper measure of the average power of the freight engines now in use; but if we assume 300 tons gross for the maximum load on a level at all seasons of the year, of engines of the medium class—from ten to twelve tons weight—we shall not be too low for the present condition of the machine, and the average power of all good engines of that class.

With this addition to the *data* of the problem, we shall have

$$\frac{T'}{10000} \qquad (E)$$

for the annual value, in dollars, of one foot in the acclivity of the maximum, or limiting, gradient.

If we now capitalize this quantity, or determine from it the original outlay of capital which would be justifiable in order to avoid an increase in the ascent of *one foot per mile*, we shall find it to be

$$\frac{1}{600} \text{ of a dollar,} \qquad (F)$$

or $1\frac{2}{3}$ *mills for each gross ton carried one mile*—the value of money being taken at 6 per cent.

In other words, to find the value of any reduction of the acclivity of the limiting grade, on ordinary railroads,

We multiply the number of tons gross carried up that grade in full trains by the length of the line (or by the distance run by the engines which cross the grade in question,) *and by the number of feet per mile in the ascent which it is proposed to save, and divide by* 600. The result will be the value of the reduction of the grade, in dollars.

There is one point in this annunciation, worthy of remark, and which I believe is never regarded in the consideration of such subjects—if indeed this question itself has ever received any consideration. The amount which may be paid, or ought to be expended, for the reduction of the maximum grade, *is proportional to the length of the road*, if the engines run "through;" or proportional to the length of the "stage" on which the gradient is found, if the line be very long and divided into stages. And this law will continue to apply until it becomes more economical to employ one or more assistant engine to aid in the ascent of such grades; in which case the value of these auxiliary

engines, or the expenses which they involve, limits the sum which may be expended in the reduction of the acclivity.

For the purpose of an application of the rule which I have announced, let us suppose that the road is thirty miles in length; that the duty to be exacted of the engines is equivalent to 20,000 tons gross conveyed "through" in the direction to which the limiting gradient is opposed; and that the cheapest admissable line would present a gradient of fifty feet per mile. How much could we afford to expend, in the construction of the road, in order to reduce this limit to forty feet? By the formula (F) we have

$$\frac{20{,}000 \times 30 \times 10}{600} = \$\,10{,}000.$$

The comparison of this result with the cost which would be actually required, under the circumstances, controls the location. But if the trade in this case had been assumed at 200,000 gross tons, and the length of the line sixty miles, the value of ten feet per mile in the limiting gradient would have been

$$\frac{200{,}000 \times 60 \times 10}{600} = \$\,200{,}000.$$

The magnitude of this last result would, of course, bring up the question of the relative economy of auxiliary power, which would be wholly inadmissible in the former case. Should the comparison determine in favour of assistant engines for the limiting gradient, our equation would then become applicable again to the determination of the value of the next highest gradient, or the sum which might be expended in its reduction.

(To be continued.)

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Further Notice of the Projected Water Works at Albany.

Mr. Cushman's letter, inserted in the last number of this journal, in which he declares himself "rather pleased the plan should have met with opposition," induces us to offer a few more remarks, with the view of reinforcing some of the positions taken in a review of these proposed works, inserted in the June number.

We will merely premise by saying, that if we have at all *misconstrued* the nature of the plans proposed, it was certainly unintentional, and may probably be owing to the ambiguity of the style in which they were described; of which we could offer examples if mere verbal criticism had any place among our objects.

Whether we have, or have not, *misconceived*, "*what really are the*

results of practice," as is alleged, we freely leave to the decision of our practical readers, most of whom are perfectly cognizant of the facts, upon which our former observations were grounded.

For the sake of convenience, we will still observe the same numerical order, in those of the few paragraphs concerning which further observations are offered, as was observed in the former review, and followed in the letter inserted in the last number.

I. *Concerning the proposed Street Jets for Extinguishing Fires in Albany.*

Mr. Cushman (at page four of the printed report forwarded to the Institute) says "for the extinguishment of fires, *effectually and expeditiously, without other power than that derived from the head of water,* it will be necessary to command a greater head than would suffice to deliver water upon the roofs by a hose or conduit pipe reaching to the roof itself."—"It should be great enough to force upon the roof a *jet d'eau* by means of a short hose applied to the hydrant, &c.," and upon page 5 of the report, he further says, "*an additional ten feet,* at the fountain, will enable us to accomplish this important purpose, *as perfectly as is possible by any exertion of power, &c.*"

Now the parts of the above extracts, which we have taken the liberty of *italicising,* show clearly enough; *first,* a design to dispense entirely with fire engines! and *second,* an expectation that jets through hose from the streets, will rise within ten feet of the altitude of the head of water which actuates them, (or height to which the water would rise in a standing pipe,) that head being either fifty-five feet, "*within the city limits,*" or near 260 feet "*in the lower part of the city,*" according as we take *the report,* or *the letter* as authority!

It was to combat these apparently erroneous doctrines, that we advanced the case of the jet d'eau at Fairmount, which from what information we then had, was supposed to play only about thirty feet under a head of nearly eighty feet; since then, by the aid of a good theodolite, we have ascertained that when the full opening is drawn, of all its cocks, this jet, actuated by seventy-five feet head, rises forty-five feet high into the air, or falls thirty feet short of the level of the reservoir.

All that we alleged, however, in the former review, viz. that although this fountain is under very favourable circumstances for producing a high ascension of water, yet "*such a jet as might have been expected does not result,*" is still borne out, by the accurate measurements recently made; for (not to multiply authorities) we find by resorting, for example, to Professor Renwick's Treatise on Mechanics

that the altitude of this jet, if deduced from the formula there given, viz:

$$H = \frac{h^2}{360} + h$$

—where H = the head of water above the ajutage, and h = the height of the jet—*should be* sixty-four feet for a head of seventy-five feet—*it is* really but forty-five feet, the practical defect being nineteen feet. Were we not justified then in saying that its altitude is less than "*might have been expected?*" And will not the jets at Albany probably fall short as much?

In fact we might, with apparent safety, infer that the *street jets* at Albany, will fall still more short of the altitude of their active head, than does the one at Fairmount; for it must not be overlooked, that although the form of the ajutage of the latter is not the most favorable possible, for producing the highest projection of water, it is yet more so than the common branch pipe of a hose, as will be readily appreciated.

Again it is perfectly well known here, that notwithstanding the abundance of our usual supply of water, whenever a great fire breaks out, and the fire department have made their attachments to the fire plugs, it is with the greatest difficulty that any water can be procured from the private hydrants in the vicinity, though these are but little elevated above the pavement, and usually about sixty feet below the level of the surface of the reservoirs at Fairmount; and we may further mention, that the ordinary consumption of the city, prevents the water from rising, in *a standing pipe*, at the Navy Yard, on the Delaware front, within nearer than about fourteen feet of the reservoir level; now if projected from the pavement by a hose, it would of course fall much more short—probably, indeed, forty feet short in all—and as the usual city supply must go on at all times when it is required, how can only ten feet additional head be expected to control fires by *street jets?*

Of course isolated cases will, and do sometimes, occur, when a single hose attached *promptly*, may subdue a fire in its inchoative state; but they are not common, and it would certainly never answer, to rest the safety of a large city upon the possible contingency of attacking every fire, in its very inception; an apparatus must therefore be kept, and a department organized, capable of making head against, and extinguishing, a considerable conflagration; and being so kept, and always ready to act, the occasional importance of a single jet, dwindles into insignificance, or even vanishes entirely.

Mr Cushman, in his letter p. 147, in speaking of the fountain at

Fairmount, says: "Now the *essential circumstance* of the trial having been made with a single ajutage of *one inch* in diameter, has been entirely overlooked, while it is 'a stubborn fact' that with a plentiful supply of water and given height of fountain, *the height of the jet may be increased* through *a very great range*, simply by varying the size of the orifice of the ajutage. My plan had due reference to this appropriate orifice for the jet, and the writer's opposition to it arises from a want of knowledge of any such requirement."

Upon this very point in Cavallo's Philosophy, p. 221, 4th Am. Ed., we find the following remarks.

"By enlarging the aperture the friction against the sides is diminished, but the friction or opposition of the air is increased. Therefore as long as the former is diminished faster than the latter is increased, the jet may be made to ascend higher and higher, by enlarging the aperture; but beyond that limit, the enlargement of the aperture will not increase the height of the jet. Now it has been found *from a variety of experiments*, that this limit, or maximum of effect, takes place when the diameter of the circular aperture *is somewhat less than an inch and a quarter.*"

Now as it seems absurd to suppose that to produce "*a very great range*," in speaking of a *one inch* jet, Mr. Cushman intended only *one quarter of an inch* variation in the size of the orifice of the ajutage, and as Mr. Cavallo explicitly declares, in the above extract, that the ajutage of a jet of maximum altitude, with a given head, *requires* to be one and a quarter inch *only*, we are impelled to the conclusion that the phrase "*very great range, &c.*," could only have been used in this connexion, from "*a want of knowledge of any such requirement.*"

Be this as it may, we *did not* mistake the "individual fact" at Fairmount for "*a principle*," as is alleged, but merely regarded it as *an instructive example, pregnant with meaning;* hence we feel but little interest in this part of the discussion, and leaving Mr. Cushman to settle with Mr. Cavallo the question of variation in the size of the ajutage, and the extent of range through which jets may thereby be augmented in altitude, we will now pass to other points.

III. *Of the thickness of Cast Iron Conduit Pipes.*

In commenting upon this subject in our review, we referred to the fact, that *long practice* had established the necessity of giving to conduit pipes, a thickness *very much greater* than would be deduced by a mere calculation, based, in any given case, upon the known working pressure of water, the known tenacity of cast iron, and perhaps a small addition for corrosion.

In our review we attempted, upon sheer practical grounds, to combat the fatal doctrine, that "one-twentieth of an inch is amply sufficient to sustain the pressure resulting from a head of fifty-five feet," even if subsequently proposed (on account of probable corrosion) to be augmented fivefold, or only to *one-fourth of an inch in thickness*, for cast iron conduits of seventeen inches calibre, working under fifty-five feet head!

Far from regarding such pipes as possessing so large a surplus of substance that "we may certainly rely upon the efficiency and durability of the conduit" if working under fifty-five feet head; we were impelled to conclude from practice here, that such a conduit would *necessarily fail* to realize the expectations formed of its utility.

For it is to guard against contingencies from without, as well as the pressure from within, that experience has shown a thickness of *two-thirds of an inch*, to be indispensable for our water pipes of sixteen inches calibre, working in the general plane of the city, under a pressure about the same as is proposed at Albany; amongst the chief of these contingencies may be named the settlement of the earth above them, in which they are buried; it would appear that the hubs, or projections, at the end of each nine feet length of the conduit pipes, rest usually upon a solid foundation formed of undisturbed earth, whilst the body of the pipe often scarcely touches at all, it being very difficult so to pack the earth around, and below it, as to secure an uniform bearing.

To show what great errors we should fall into, by founding an estimate of the necessary thickness of conduit pipes upon a mere calculation of the pressure within them, we will refer to the case of the gas pipes of Philadelphia, which work under a pressure equivalent only *to three inches head of water;* now these pipes, if proportioned to the pressure within, upon the supposition that "one-twentieth of an inch is amply sufficient" to sustain a head of fifty-five feet (as stated on p. 15 of the printed report) would scarcely be thicker than this sheet of paper! Let us inquire what is the actual thickness in use in Philadelphia? The able superintendent of the gas works has informed the writer, that their sixteen inch mains are made about five-eighths of an inch thick, and that, as a general rule, they give to the gas conduits *only ten per cent. less substance than practice has assigned to those of similar calibre which convey water through the city.*

Such being the case here, we invite our readers to calculate the minute fraction of an inch, which would represent the thickness of cast iron gas pipes, upon the supposition that *the pressure alone* should be regarded, and ask themselves whether such attenuated tubes could be, for a moment, thought of *for actual use;* for we may probably be

told that the thickness commonly allowed for gas pipes *every where*, which far exceeds what the mere pressure within would require, is one of the "errors of practice" that ought to be repudiated; though such an allegation would more likely be regarded by impartial people as *an error* in him who ventured the assertion.

V. *Concerning the separate lengths of the Conduit Pipes.*

The fact that in practice the hubs of pipes are likely to, and do often actually, become fixed points of support, is a very strong argument (amongst others) against increasing their length from nine to fifteen feet; more especially, when at the very same time that it is proposed to increase the lengths of the pipes, and thus essentially augment the stress upon them; it is also (most singularly) proposed, greatly to reduce the thickness assigned them by practice, so as very much to diminish their ability *to support that augmented strain!*

VII. *Concerning the velocity of the water in the main rising from the pumps.*

The writer has been informed on good authority, that soon after the present works at Fairmount were first put in operation, numerous experiments were made with the view of determining the most advantageous velocity at which to work the wheels and forcing pumps; these trials were commenced with about fifteen revolutions per minute of the wheel, when driving the double forcing pump with five feet stroke each way, or with a velocity of water in the rising main of 150 feet per minute; at which speed every thing worked smoothly and well; but as this celerity gave to the wheel, at the skirt, a velocity of nearly twelve feet per second, it was thought desirable to diminish it; and accordingly trials were made, by reducing the motion successively, one revolution at a time, until the number of turns of the wheel in a minute was reduced to twelve, or the speed in the rising main to 120 feet per minute; *still all worked well*, and so continued until the speed was somewhat further reduced; but it was soon after discovered that during the instants of time, when the piston was changing its direction at either end of the pump barrel, a recoil of the ascending column began to take place at these intervals; *owing to the momentum not being kept up whilst the piston cleared its dead points;* and when the speed was reduced as low as eight turns of the wheel in a minute, or the ascending rate to a velocity of eighty feet per minute, (still fifteen feet per minute *greater* than is proposed at Albany,) the recoil at each end of every stroke of the force pump, became so serious as to cause the shocks to be very perceptible, like the pulsations of an hydraulic ram, the joints of the pump began to open and leak, and the successive shocks threatening to blow up the working tube, the

experiments were discontinued by the superintendent; he having satisfied himself *that a velocity of about* 120 *feet per minute for the water in the rising main,* was, in view of every thing, the most suitable speed at which to operate these works.

This is not a *theoretical* conclusion, but *an experimental result* of a very significant character; one that will neither be misunderstood, nor disregarded, by any practical man who feels a proper anxiety for the success of works committed to his charge; and we submit, whether it does not entirely justify the remarks formerly made by us upon this point.

Finally, being quite content to rest the case, in connexion with the other points mentioned in our review in the June number, upon the issues made upon the arguments formerly advanced, and having already occupied, with these remarks, much more space than had been originally designed, we will now take a final leave of the subject by expressing the hope, that before the "Projected Water Works at Albany" are put in hand for execution, *the plan* may be more maturely considered by the respected engineer, lest in after times some future projector of water works, may point to them as instructive examples of "*the errors of practice.*" M.

Facts and Observations on Four and Six Wheel Engines. By JOHN HERAPATH, ESQ.

[CONTINUED FROM PAGE 160.]

Glasgow and Ayr Railway.—This is one of the lines upon which I was unable to go, but respecting the locomotives of which, however, I have been favoured with some information. The total length of this line is forty miles, as it appears from an article on the Glasgow and Ayr Railway, in the 35th No. of the octavo series of the R. M.; that is, seven miles from Glasgow to Paisley, ten to Johnstone, fifteen to Lochwinnoch, nineteen to Beith, twenty to Kilburnie, twenty-three to Dalby, twenty-nine to Kilwinning, thirty to Irvine, thirty-three to Troon, and forty to Ayr. The present amount expended is something under £ 20,000 per mile.

The steepest gradient of this line is eleven and three-fourths feet a mile, and there is no sharper curve than a mile radius, except at the Glasgow terminus, where it is 1200 feet. For the curve of a mile radius the outer rail is elevated three-fourths of an inch. The locomotive stock of the Glasgow and Ayr Railway, consists of twenty engines; eight made upon Mr. Bury's plan, that is four wheel engines, with inside bearings, and the other twelve are made upon the plan of the Company's Engineer, Mr. Miller. These are six wheel engines, and have inside bearings. The weight of the six wheel is thirteen and a half tons; their weight on the driving wheels is six tons, (query, seven tons) and on the other wheels three and a quarter tons each.

The weight of the uncoupled four wheels is ten tons, and of the only two coupled engines they appear to have, thirteen tons, of which the weight on the driving wheels of the uncoupled four wheels is six tons, and on the other wheels four tons. In the coupled engines the weight is equally distributed.

Of these engines nineteen are in a fit state to leave the station with a train, and the twentieth one, at the end of November last, was expected to be ready in a few days. The driving wheels on the six wheel engines have flanches seven-eighths of an inch deep.

The motion of the coupled engines is less than those four wheel that are not coupled, but it is not thought they have sufficient experience in these matters to speak as to the particular safety or danger of either kind.

From August twelve months, the time the line was opened from Glasgow to Ayr, they have not had more than three detentions on account of derangement of machinery. In neither of these cases was the engine thrown off the line, the detention having been from some very slight breakage in the machinery, or the pumps being out of order, nor has there been any, the slightest, accident to carriages or passengers.

There have been no broken axles whatever.

From the time of the opening to Glasgow, three engines have been thrown off the rails, at the switches near the stopping places, or stations. Two on account of the switchmen having pointed the rails wrong as the engine was entering the station, and the other on account of the connecting rod of the two switch bars having got too much play. In no instance has any damage been done to any passenger, or servant of the Company, or to any carriage. These accidents happened, one with a six wheel engine, and two with a four wheel, all uncoupled. All the driving wheels are five and a half feet diameter, except the two coupled engines, which are five feet. They have thirteen inch cylinders, eighteen inch stroke. The gauge of the rails is four feet eight and a half inches, and the play of the wheels on the rails is half an inch, and the pressure per square inch fifty pounds. The average cost of the six wheel engines is £ 1,320, and of the four wheel £ 1,400. They find the four wheel engines more economical in point of consumption of coke, but in no other respect do they conceive that one kind of engine has any advantage over another. The six wheel consumes forty-two pounds of coke per mile, and eighteen gallons of water; the four wheel forty pounds of coke per mile, and sixteen gallons of water.

Motion is said to be more conspicuous in their four wheel engines than in their six. The four wheel has a slight vertical motion, the six wheel a slight lateral motion, but the engines run so very steadily that motion is scarcely perceptible. These motions, however, whatever they are, they think are due chiefly to the imperfections of the road. The length of their six wheel engines is eighteen feet, and of their four wheel sixteen feet. They have no practical proof that the distance of the cranks from the middle of their axles produces any sinuous or sidling motion. Total mileage per annum is 130,000.

Maryport and Carlisle Railway.—Though I had a very kind invitation from William Mitchell, Esq., the Secretary, I was, for the same reasons as stated in my account of the Great North of England, Glasgow and Ayr, and Ulster Railways, unable to visit this line, which was partially opened July 15, 1830.

They have only two locomotive engines, six wheel and outside bearings. One, a coupled engine, fifteen tons, and the other, an uncoupled, thirteen tons. The coupled engine has about half the weight on the driving wheels, and the uncoupled about ten tons. One of these I understand to be coupled in all six wheels. They find it a safe engine, but the uncoupled one is of little use, for the heavy loads which they carry, namely, 140 tons. The coupled engine has flanches, and the uncoupled has not. One of these engines in November was in a fit state to take a train. They have had no detentions from failure of machinery, nor any broken crank axles, or runnings off the line. The diameter of the driving wheels of the uncoupled engines is five feet, of the coupled four and a half, the other wheels being three and a half feet in diameter. The uncoupled engine has a twelve inch cylinder, and eighteen inch stroke, the other a fourteen inch cylinder and sixteen inch stroke. The smaller engine cost £ 1,400, its tender £ 180. The larger engine and tender £ 1,720. They say the six wheel engine runs smoother on the rough road, but the four wheel takes the curves better. The average consumption of coke is sixty-seven pounds per mile, and the evaporation of water twenty-five gallons. They attribute the motions of the engines to bad road. One engine is rather top-heavy from having a high fire box. The extreme length of the engines is sixteen feet. The manager of the locomotives thinks that the distance of the cranks from the centre of the axle produces sinuous motion when the road is slippery, and much more in the uncoupled than in the coupled engine. The steam pressure is fifty-two pounds to the inch. The total distance run is 7,200 miles a year. The steepest gradient in the eight miles now opened is nineteen and one-third feet a mile, and on the part to be opened twenty-five and one-fourth feet.

At one time there was a curve on this line near the terminus of six chains radius, and with an elevation of the outer rail of only half an inch. The present secretary, Mr. Mitchell, reduced the curvature to nine chains radius, and elevated the outer rail to two inches. It is worthy of remark, that on the former curve the engine is described as having great sinuous or eel-like motion, which is now almost entirely obviated on the new curve. This is rather a curious circumstance, as I should have expected that on the curve with a larger radius the sinuous motion would have been more conspicuous. It is, therefore, a question for inquiry, whether the greater elevation of the outer rail has any thing to do with steadying the motion; for it is generally understood that the sole object of the elevation of the outer rail is to balance the centrifugal force.

I understand that the engine has often traversed this curve at the rate of twenty-two miles an hour, with a load of sixty tons after it.

The Ulster Railway.—This was another line upon which of course

I had no opportunity of going, as I did not go out of England. The length opened of this line is twenty miles.

The Company's stock consists of seven engines, all six wheel and uncoupled, with outside and inside bearings on the crank axle. They weigh sixteen tons, of which nine and a half tons are upon the driving wheels. The driving wheels have all flanches, and the whole seven of the Company's engines are in an efficient state of repair. They have had about six detentions of trains, from trifling derangements of the machinery, in two and a quarter years, but no broken crank axles, nor have they had any engine run off the line.

The average cost of their engines is £ 1,500, and of the tender £ 260. Their consumption of coke is thirty-five pounds per mile, and of water twenty-five gallons per mile. The engines are described as perfectly steady. Top-heavy engines are unknown to them.

They have no practical proofs of the influence of the distance of the cylinders from the main axis of the engine producing any effect upon the motion of the engines. The expense of repairs is 11½d. per mile per annum, and the steam pressure is sixty pounds to the inch. The gross average load is from fifty to sixty tons.

York and North Midland Railway.—As a continuation of the main trunk to the north, the York and North Midland Railway forms an important link. Starting from the junction of the North Midland and Manchester and Leeds Railways at Normanton, about ten miles south of Leeds, it pursues a north easterly course to York, crossing the Leeds and Selby Railway about fourteen miles from York, the whole length of the line being twenty-three miles fifty-two chains, or nearly twenty-three and three-fourths miles.

I have already referred, in my account of the Hull and Selby, to some of the engines of this Company upon which I have traveled. Most of them are built by Mr. Robert Stephenson. The two I traveled on with Mr. Cabrey were the *Princess* and the *Victoria*. The latter was a lively and smart engine, and in my opinion better than the former, which I thought somewhat sluggish.

The Company's stock of engines in the middle of January last was thirty-two, eleven of which were taken from the Leeds and Selby Railway when this Company became lessees of that line. The whole are on six wheels, with outside and inside bearings, except the *Prince of Wales*, the late improved patented engine of Mr. R. Stephenson. The weight of the smallest engines is twelve and a half tons. Some are between that and fourteen tons, and others are sixteen tons weight. About one-half the total weight is on the driving wheels, five-sixteenths on the fore-wheels, and the remainder on the hind wheels. They have eight coupled engines, all on six wheels, which work well, are considered safe, and not expensive, considering the loads they take. They are used exclusively for luggage trains. *Most of the engines are without flanches on the driving wheels.* Out of their number they had twenty-six in good working order, and have not averaged one detention a month from any derangement of the engines. In two years and seven months they have had *ten crank axles broken*, none of the engines being able to proceed with the train

after the fracture. The axles had for some time been failing prior to the breaking down, which was attributed to their being too weak, and in some cases to the material being defective. There was only one of these a coupled engine. Five of them broke down near the station, while moving very slowly, and of course at a great strain; the others, while ascending an easy gradient on a slight curve. No accident or injury happened to any one. In no instance has an engine run off the rails except by the points being wrong. Three of the broken axles were five inches in diameter. The cost of the engines is from £ 1,300 to £ 1,600. They give a preference to six wheel engines, thinking them safer than four wheel. The gross average weight of the passenger trains is fifty tons, and average consumption of coke twenty-five pounds per mile, and for goods trains thirty-eight pounds. The motions observed are a slight pitching, rolling, and sinuous motions, which they say are most conspicuous in ascents, descents, and curves, and always arise from imperfection in the road, assisted at times by the wheels wearing out of truth. They have no top heavy engines, nor have they any practical proof that the distance of the cranks from the centre of the axle has any effect on the sinuous or sideling motion of the engines, but Mr. Cabrey thinks it probable that if the cylinders were outside the wheels, the sideling motion would be increased.

The steam pressure is sixty pounds per square inch. The distance run by the passenger engines during a year is 289,600 miles, and by the luggage engines 212,200. Including their main line and branches, and the Leeds and Selby which they lease, they work about forty-eight miles of railway. The oldest of the York engines is three years; some of the Leeds and Selby six years, but the engineer thinks the age of the engine does not affect its steadiness, provided the engine is in good order.

It was upon this line, if I remember rightly, that I was informed by the engineer that, whenever there were any fractures of the axles of wagons, it generally happened upon the stone blocks. They are in the habit of taking coal wagons of other parties, in the make of the axles of which, so much care is not bestowed, as if they were made for the Company, and hence, when they come to travel at a rapid rate, loaded, over their line, if they are disposed to break they almost always do it were the percussive effects are the greatest, that is, upon the stone blocks. *In fact, it appears to be generally established by experience, that stone-blocks are objectionable upon railways, and more fruitful in accidents (which they occasion from their rigidity,) than either cross sleepers, or continuous wooden bearings.*

[To be continued.]

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

[CONTINUED FROM PAGE 162.]

On Retaining Walls.

LECTURE VII.—Wednesday, January 5th, 1842, Professor Vignoles commenced by stating that he had then reached the third division of

the first course, and his present lecture would be upon retaining walls. The meaning of the technical terms of "retaining" and "sustaining" walls was—when a wall was used either to support water or earth artificially put together; but when it was used to support natural earth, it was often called a "breast-work." As the term "batir" would often be made use of in that and the following lecture, he proceeded to explain that the batir was the base of a triangle, formed by the slope of the wall and perpendiculars of the other two sides—thus a battering wall was a sloping wall. The introduction of retaining walls was very ancient; in Italy there were several of great antiquity, formed of concrete, rubble, &c., and even some parts of the Great Wall of China was built in that way. Retaining walls were generally introduced at the ends of bridges, to connect the abutments of the bridge with the natural ground; but in these cases they were called "wing walls." In forming roads, retaining walls were sometimes carried along the sides of valleys—the road itself having to be cut at times along the sides of hills so precipitous, that half was embankment and half cutting. In the celebrated road formed by Napoleon across the Alps, there were many instances of work of this kind, and good lessons could be learnt from the failures which had taken place, the reasons for which were generally very apparent. In Telford's grand road through Wales, there were many instances of retaining walls, and one in particular, where the road had to pass along the side of a hill which was nearly perpendicular. The great cutting from Camdentown to Euston-square was another instance, but, from certain causes, which he very ably explained, the walls were giving way in many places. He then proceeded to lay down, by numerous diagrams, seven forms of retaining walls made use of; and pointed out, by mathematical formula and practical experiments that had been made, and which the diagrams explained, the best forms for use. In No. 1 the batir was represented as being equal on each side of the wall; in No. 2 the batir was on the side next the earth to be supported; No. 3 was a parallel batiring wall; in No. 4 the batir was next the earth, but at the bottom of the wall, No. 5, the batir was on the outside, at the top; No. 6, was a parallel and perpendicular wall, with no batir on either side; and No. 7 had the batir at the outer side of the wall, and next the earth the slope was cut in steps; these seven diagrams showed the common forms of retaining walls. The grand points to be considered, were—1st, the value of the pressure that the earth exercised against retaining walls; and, 2d, the description and dimension of the wall necessary to offer sufficient resistance to that pressure. It was found that if you take away the wall, the earth will for a short space of time retain its position, but, after exposure, it will begin with crumbling at the edges, and ultimately gain a slope so as to lie at the angle, which is called the "angle of repose;" this requires, in building retaining walls, that the angle of repose of the description of earth to be supported should be ascertained; this done, the pressure to be resisted might be calculated, and the dimensions of the wall be decided upon accordingly. Of all the descriptions of retaining walls No. 3 was the one which offered

the most support with the least quantity of material, and which had, by experiments made at Dublin under the direction of Sir J. Burgoyne and the Board of Public Works of Ireland, been fully proved. The Professor then explained the nature of the several experiments, and the effects upon the walls, exemplifying them by very instructive diagrams. The attention of the students was next called to the curvilinear batir, and several very interesting cases were adduced of failure in that plan, from various causes, but principally from water. He then alluded to two or three failures of his own, and fully explained to the students the causes of them, and the means he should have adopted in the first instance for their prevention. The occasional supporting of walls was judicious in various instances; suppose there was a case, that, while the earth was in an unsettled state, the pressure against the wall was double what it would be when it had settled; in such a case he would recommend supporting walls until the settlement took place—not to go to double the expense for a temporary purpose. He then mentioned a very remarkable instance of an abutment, which was practically a retaining wall, giving way. He had to make an arch of twenty feet span for a river, through an embankment eighty feet high; the foundation was rock, but a sudden lurch took place in the body of the embankment, and the earth forced its way through very many feet of sand backing, drove the abutment or retaining wall clean off the rock, and moved the whole twelve or thirteen feet. Several good rules were then laid down to calculate the description of wall to be used, and method of giving a temporary support until the earth settled; and the learned lecturer, in conclusion, stated that his next lecture would be given on Wormwood Scrubbs, where there were some most remarkable instances of failures in retaining walls, the reason of which he could better explain on the spot than by diagrams.

On Atmospheric Railways.

Lecture VIII.—Monday, January 10th, 1842.—This being intended as a practical illustration of some interesting and important points, the lecture was delivered on the works of the railways situated at, or near, Wormwood Scrubbs, in place of being given, as usual, in the lecture room of University College.

The first point to which Mr. Vignoles directed the attention of the class was to the atmospheric railway, or rather a portion of railway laid down on that principle for experimental purposes, upon the line belonging to the West London Railway Company. The length of this experimental line is half a mile, and, according to the Professor's statement, it fully answered the purpose, and he, at some length, and with great ingenuity, explained the principles of the system. The iron tube first attracted attention; it is nine inches in diameter, with a grooved slit along the upper surface, which is closed by means of a valve of leather, strengthened by plates of iron, flat on the outside, and forming the segment of a circle on the inside, so as to complete the diameter of the tube when it is shut; at the edge of the valve is a composition of bees' wax and tallow, which renders the tube air tight.

Next was examined the carriage, to which was attached a piston, fitting into the tube, and a very ingenious contrivance was shown, by which the valve was first opened and afterwards closed down, immediately after the piston had passed, however great the velocity of the carriage. The impossibility of procuring a perfect vacuum had long been assigned as the great objection to this principle of producing locomotion; but Professor Vignoles showed that a good working half vacuum was, by the simple contrivance he had explained, quite attainable, and sufficient for practical purposes. The engine and air-pump were next severally examined and explained, and the lecturer then gave some very interesting explanations of matters connected with the present experimental railway; he stated that the air from the half mile of tube could be extracted in about one minute, while it would take nearly eight minutes for the leakage of the valve and air-tube to admit the air to fill the tube. In consequence of the imperfections in the present line, which had been merely laid down for experiment, the leakage was very much more considerable than when a perfect line should be formed for service, and the formation of a railway on the atmospheric principle would not exceed, perhaps, one-third of the cost of many of the great lines hitherto contracted for, as it would do away with much of the cutting and embankment, the slips of which had recently been so troublesome and dangerous, by the trains being able, on this method, to ascend considerable acclivities. The present experimental line had a rise of about one foot in 110, and he had gone along at the rate of forty-five miles an hour, notwithstanding the imperfections of the machinery and the wretched state of the line; he pointed out that it would be practicably impossible for a locomotive to travel upon such a line, as it would be off the rails immediately, in consequence of their being so uneven and loose; yet he had traveled at the rate he before mentioned, with perfect ease and safety; and, furthermore, the extreme simplicity of the machinery rendered it very unlikely to get out of order. A few weeks back the line was required suddenly for some experiment, and, although the tube was half full of ice, in less than half an hour every thing was in readiness, and the trial was very satisfactory. The power obtained by the present small tube is 1760 lbs., with an atmospheric pressure of about eight pounds per inch only. The engine employed to work the air-pump is sixteen or eighteen horse power, and the economy of stationary over locomotive power was admitted by every body. He concluded his remarks upon this interesting, and what promises to be most useful, application of the power of atmospheric pressure, by detailing, at some length, the minutiæ of the saving that would be effected by its general adoption, and stating that two miles were to be laid down upon the Dublin and Kingstown Railway, to try the experiment upon a larger scale, with a tube fifteen inches in diameter, and more perfect apparatus. The Professor then, as the party walked along the line, pointed out to the class various slips that had taken place, some of which were slight, and others extensive; one part in particular, situated between the Great Western and London and Birmingham Railways (which are here within a quarter of a mile of each

other,) attracted general attention, the whole, for nearly 100 yards, being a perfect chaos. A remarkable instance of a failure of a retaining wall here presented itself, it having, for about forty-five yards, been actually pushed forward off the foundation, to a distance of eight or ten feet, the wall still standing, which appeared to be about four feet thick, strongly built of brick and concrete and strengthened with bands of iron and wood. The causes of this destruction were explained by Mr. Vignoles as arising from the lodgment of water, which, having no outlet, had settled the earth against the back of the retaining wall, turning the clay into mud, and, by the great additional weight, forcing it into the position in which it now appears. If the water had been cut off in time this would not have happened, and that water was the occasion of this accident seemed very apparent. The lecturer then pointed out the manner of supporting retaining walls. Several portions of the London and Birmingham and Great Western Railways were then examined, and much valuable information was given on the various contrivances made use of by these companies, and he concluded by appointing the class to meet on the Croydon and Brighton Railways the next morning, to proceed to the great slip near New Cross.

[TO BE CONTINUED.]

Physical Science.

On the Chemical Statics of Organized Beings. Extract from the concluding Lecture, in L'Ecole de Médecine in Paris. By M. DUMAS.

[CONCLUDED FROM PAGE 175.]

V. An animal, in fact, constitutes an apparatus of combustion from which carbonic acid is continually disengaged, in which, consequently, carbon undergoes combustion.

You know that we were not stopped by the expression *cold-blooded animals*, which would seem to designate some animals destitute of the property of producing heat. Iron which burns vividly in oxygen produces a heat which no one would deny; but reflection and some science are necessary in order to perceive that iron which rusts slowly in the air disengages quite as much, although its temperature does not sensibly vary. No one doubts that lighted phosphorus in burning produces a great quantity of heat. Unkindled phosphorus also burns in the air, and yet the heat which it developes in this state was for a long time disputed.

So as to animals; those which are called warm-blooded burn much carbon in a given time, and preserve a sensible excess of heat above the surrounding bodies; those which are termed cold-blooded burn much less carbon, and consequently retain so slight an excess of heat, that it becomes difficult or impossible to observe it.

But, nevertheless, reflection shows us that the most constant character of animal existence resides in this combustion of carbon, and in the development of carbonic acid which is the result of it; beginning,

also, in the production of heat, which every combustion of carbon occasions.

Whether the question be of superior or inferior animals; whether this carbonic acid be exhaled from the lungs or from the skin, does not signify; it is always the same phenomenon, the same function.

At the same time that animals burn carbon, they also burn hydrogen; this is a point proved by the constant disappearance of hydrogen which takes place in their respiration.

Besides, they continually exhale azote. I insist upon this point, and principally in order to banish an illusion which I cannot but believe to be one of the most prejudicial to your studies. Some observers have admitted that there is an absorption of azote in respiration, but which never appears unaccompanied by circumstances that render it more than doubtful. The constant phenomenon is the exhalation of this gas.

We must therefore conclude with certainty, that we never borrow azote from the air; that the air is never an aliment to us; and that we merely take from it the oxygen necessary to form carbonic acid with our carbon, and water with our hydrogen.

The azote exhaled proceeds, then, from the aliments, and it originates in them entirely. This, in the general economy of nature, may in thousands of centuries be absorbed by plants which, like Jerusalem artichokes, draw their azote directly from the air.

But this is not all the azote which animals exhale. Every one gives out by the urine, on an average, as M. Lecanu has proved, 230 grains of azote a day, of azote evidently drawn from our food, like the carbon and hydrogen which are oxidised within us (que nous brûlons.)

In what form does this azote escape? In the form of ammonia. Here, indeed, one of those observations presents itself which never fail to fill us with admiration for the simplicity of the means which nature puts in operation.

If in the general order of things we return to the air the azote which certain vegetables may sometimes directly make use of, it ought to happen that we should also be bound to return ammonia, a product so necessary to the existence and development of most vegetables.

Such is the principal result of the urinary secretion. It is an emission of ammonia, which returns to the soil or to the air.

But is there any need to remark here, that the urinary organs would be changed in their functions and in their vitality by the contact of ammonia? the contact of the carbonate of ammonia would even effect this; and so nature causes us to excrete urea.

Urea is carbonate of ammonia, that is to say, carbonic acid like that which we expire, and ammonia such as plants require. But this carbonate of ammonia has lost of hydrogen and oxygen so much as is wanting to constitute two molecules of water.

Deprived of this water the carbonate of ammonia becomes urea; then it is neutral, not acting upon the animal membranes; then it may pass through the kidneys, the ureters, and the bladder, without inflaming them: but, having reached the air, it undergoes a true fermentation, which restores to it these two molecules of water, and which

makes of this same urea true carbonate of ammonia; volatile, capable of exhaling in the air; soluble, so that it may be taken up again by rain; and consequently destined thus to travel from the earth to the air, and from the air to the earth, until, pumped up by the roots of a plant and elaborated by it, it is converted anew into an organic matter.

Let us add another feature to this picture. In the urine, along with urea, nature has placed some traces of albuminous or mucous animal matter, traces of which are barely sensible to analysis. This, however, when it has reached the air, is there modified, and becomes one of those ferments of which we find so many in organic nature; it is this which determines the conversion of urea into carbonate of ammonia.

These ferments, which have so powerfully attracted our attention, and which preside over the most remarkable metamorphoses of organic chemistry, I reserve for the next year, when I shall give you a still more particular and full account of them.

Thus we discharge urea accompanied by this ferment, by this artifice, which, acting at a given moment, turns this urea into carbonate of ammonia.

If we restore to the general phenomenon of animal combustion that carbonic acid of the carbonate of ammonia which of right belongs to it, there remains ammonia as the characteristic product of urine.

Thus, by the lungs and the skin, carbonic acid, water, azote.

By the urine, ammonia.

Such are the constant and necessary products which exhale from the animal.

These are precisely those which vegetation demands and makes use of, just as the vegetable in its turn gives back to the air the oxygen which the animal has consumed.

Whence come this carbon, this hydrogen burnt by the animal, this azote which it has exhaled in a free state or converted into ammonia? They evidently come from the aliments.

By studying digestion in this point of view, we have been led to consider it in a manner much more simple than is customary, and which may be summed up in a few words.

In fact, as soon as it was proved to us that the animal creates no organic matter; that it merely assimilates or expends it by burning it (en la brûlant,) there was no occasion to seek in digestion all those mysteries which we were quite sure of not finding there.

Thus, digestion is indeed but a simple function of absorption. The soluble matters pass into the blood, for the most part unchanged; the insoluble matters reach the chyle, sufficiently divided to be taken up by the orifices of the chyliferous vessels.

Besides, the evident object of digestion is to restore to the blood a matter proper for supplying our respiration with the ten or fifteen grains of coal, or the equivalent of hydrogen, which each of us burns every hour; and to restore to it the grain of azote which is also hourly exhaled, as well by the lungs or the skin as by the urine.

Thus the amylaceous matters are changed into gum and sugar; the saccharine matters are absorbed.

The fatty matters are divided, and converted into an emulsion, and thus pass into the vessels, in order to forms depôts which the blood takes back and burns as it needs.

The neutral azotated substances, fibrin, albumen, and caseum, which are at first dissolved, and then precipitated, pass into the chyle greatly divided, or dissolved anew.

The animal thus receives and assimilates, almost unaltered, the azotated neutral substances which it finds ready formed in the animals or plants upon which it feeds; it receives fatty matters, which come from the same sources; it receives amylaceous or saccharine matters, which are in the same predicament.

These three great orders of matters, whose origin always ascends to the plant, become divided into products capable of being assimilated, fibrin, albumen, caseum, fatty bodies which serve to renew or recruit the organs with the combustible products, sugar and fatty bodies which respiration consumes.

The animal therefore assimilates or destroys organic matters ready formed; it does not create them.

Digestion introduces into the blood organic matters ready formed; assimilation employs those which are azotated; respiration burns the others.

If animals do not possess any peculiar power for producing organic matters, have they at least that special and singular power which has been attributed to them, of producing heat without expenditure of matter?

You have seen, while discussing the experiments of MM. Dulong and Despretz, you have positively seen the contrary results from them. These skilful physicists supposed that an animal placed in a cold water calorimeter comes out of it with the same temperature that it had on entering it; a thing absolutely impossible, as is now well known. It is this cooling of the animal, of which they took no account, that expresses in their *tableaux* the excess of heat, attributed by them and by all physiologists, to a calorific power peculiar to the animal, and independent of respiration.

It is evident to me that all animal heat arises from respiration; that it is measured by the carbon and hydrogen burnt. In a word it is evident to me that the poetical comparison of a railroad locomotive to an animal, is founded on a more serious basis than has, perhaps, been supposed. In each, there are combustion, heat, motion; three phenomena connected and proportional.

You see that, thus considering it, the animal machine becomes much easier to understand; it is the intermediary between the vegetable kingdom and the air; it borrows all its aliments from the one, in order to give all its excretions to the other.

Shall I remind you how we viewed respiration, a phenomenon more complex than Laplace and Lavoisier had thought, or even Lagrange had supposed, but which, precisely as it becomes complicated, tends more and more to enter into the general laws of inanimate nature?

You have seen that the venous blood dissolves oxygen and disengages carbonic acid; that it becomes arterial without producing a trace of heat. It is not, then, in becoming arterial, that the blood produces heat.

But under the influence of the oxygen absorbed, the soluble matters of the blood change into lactic acid, as MM. Mitscherlich, Boutron-Charlard, and Fremy observed; the lactic acid is itself converted into lactate of soda; this latter, by a real combustion, into carbonate of soda, which a fresh portion of lactic acid decomposes in its turn. This slow and continued succession of phenomena which constitutes a real combustion, but decomposed at several times, in which we see one of the slow combustions to which M. Chevreul drew attention long ago, this is the true phenomena of respiration. The blood then becomes oxygenised in the lungs; it really breathes in the capillaries of all the other organs, there where the combustion of carbon and the production of heat principally take place.

A last reflection. To ascend to the summit of Mont Blanc, a man takes two days of twelve hours. During this time he burns at an average 300 grammes of carbon, or the equivalent of hydrogen. If a steam engine had been employed to take him there, it would have burnt from 1,000 to 1,200 to accomplish the same work.

Thus, viewed as a machine, borrowing all its power from the coal that it burns, man is an engine three or four times more perfect than the most perfect steam engine. Our engineers have, therefore, still much to do; and yet these numbers are quite such as to prove that there is a community of principles between the living engine and the other; for, if we allow for all the inevitable losses in steam engines which are so carefully avoided in the human machine, the identity of the principle of their respective powers appears manifest and clear.

But we have followed far enough considerations as to which your own reflections are already in advance of me, and where your recollections leave me nothing more to do.

To sum up, then, we see that of the primitive atmosphere of the earth, three great parts have been formed:

One which constitutes the actual atmospheric air; the second, which is represented by vegetables; the third, by animals.

Between these three masses, continual exchanges take place; matter descends from the air into plants, enters by this route into animals, and returns to the air according as these make use of it.

Green vegetables constitute the great laboratory of organic chemistry. It is they which, with carbon, hydrogen, azote, water and oxide of ammonium, slowly build up all the most complex organic matters. They receive from the solar rays, under the form of heat or of chemical rays, the powers necessary for this work.

Animals assimilate, or absorb, the organic matters formed by plants. They change them by little and little; they destroy them. In their organs, new organic substances may come into existence, but they are always substances more simple, more akin to the elementary state, than those which they have received. By degrees these decompose the organic matters slowly created by plants; they bring them back,

little by little, towards the state of carbonic acid, water, azote, and ammonia, a state which allows them to be returned to the air.

In burning or destroying these organic matters, animals always produce heat, which, radiating from their bodies in space, goes to supply the place of that which vegetables had absorbed.

Thus all that air gives to plants, plants give up to animals, and animals restore to the air; an eternal circle, in which life keeps in motion and manifests itself, but in which matter merely changes place.

The brute matter of air, organized by slow degrees in plants, comes, then, to perform its part without change in animals, and serves as an instrument for thought; then, vanquised by this effort, and broken as it were, it returns brute matter to the great reservoir whence it came.

Allow me to add, in finishing this picture, which sums up opinions, which, to my mind, are but the necessary consequences and developments of the great path which Lavoisier marked out for modern chemistry; allow me, I say, to express myself as he did with regard to his fellow labourers and his friends.

If in my lessons, if in this summing up, I have chanced to adopt, without mentioning it, the experiments or the opinions of M. Boussingault, it is that the habit of communicating to each other our ideas, our observations, our manner of viewing things, has established between us a community of opinions, in which we ourselves, even afterwards, find it difficult to distinguish what belongs to each of us.

In resting these opinions and their consequences on his name and on his authority, in telling you that we work actively, sometimes together, and sometimes apart, in order to verify and to develope all these facts, all these results, by experiment, I do but evince my anxious desire to justify the interest which you have this year taken in my labours.

For this I beg to thank you. It has given me courage to undertake a long course of researches: if anything useful to the progress of humanity should result from them, let all the honour of it redound to the intelligent good-will with which you have constantly surrounded me, and for which I shall ever be profoundly grateful.

[From the American Journal of Science for October.*]

On the Evidence of a general Whirling Action in the Providence Tornado. *By* W. C. Redfield.

On the 30th of August, 1838, between the hours of 3 and 4 P. M., a violent whirlwind, or tornado, visited the town of Providence, in the State of Rhode Island. It was preceded by a shower of rain of short duration, after which the tornado appeared, appended to another cloud, and passed through the southern part of the town nearly from west to east.

Its earliest ravages reported, were in Johnston, at the farm of Mr. Randall, about seven miles west from Providence. From this point it passed on through Cranston and Providence, where, crossing the river into the State of Massachusetts, it passed through Seekonk, Re-

* Communicated by the Author for the Journal of the Franklin Institute.

hoboth, Swansey, Somerset, and as far, at least, as Freetown, beyond Taunton river; a distance of twenty-five miles from the point first mentioned.

The width of its visible track, as indicated by the prostration of trees, fences, and other objects, varied from a mere trace in its narrowest, to two hundred yards or upwards in its widest portions. Having, a few days after the occurrence of the tornado, carefully examined the track for the distance of about seven miles, on each side of Providence river, I propose to offer some of the results of this examination, together with such remarks as may seem justly deducible from the effects observed.

So far, however, as the impressions made on an accidental eye-witness of the tornado may be important, we have a valuable account furnished us in the letter of Zachariah Allen, Esq., of Providence, which is given in Dr. Hare's notice of this tornado. [Silliman's Journal, vol. xxxviii, p. 74–77.] Mr. Allen had the advantage of viewing its progress from a point near its path. He calls it a "whirlwind," and describes its phenomena in a manner perfectly consistent with this appellation. "The circle formed by the tornado" on the river, he describes as "about three hundred feet in diameter," and mentions, that the "misty vapors" . . . "entering the whirling vortex, at times veiled from sight the centre of the circle, and the lower extremity of the overhanging cone of dark vapor:" and that "amid all the agitation of the water and the air about it, this cone continued unbroken," &c.

This "cone" of the tornado of which he so often speaks, it should be noted was an *inverted* one, the smaller end of which was sweeping on the earth's surface.* Thus he gives the instance, "when the point of the dark cone of cloud passed over the prostrate wreck of the building, the fragments seemed to be upheaved," &c. It will be seen here that the *prostration* of the building had preceded the arrival of the centre or "point" of the "cone;" showing that the whirlwind often acts on a large area, with great force, *externally* to the lower part of the *visible* cone, or the column of vapor at its axis. Moreover, the substances which by the centre of the tornado were "uplifted high in the air," were "left to fall from the OUTER EDGE of the black conical cloud."†

Mr. Allen says further, "The progress of the tornado was nearly in

* We may properly conceive of this "cone," in tornadoes or water-spouts, as including not only the visible, clouded condensation here described, but also the invisible portion of the whirlwind which surrounds the narrow and depending portion of the visible cone, below the general line of condensation. Thus the *entire* body of the whirlwind is generally a truncated cone; its smaller and most active end sweeping along the surface of the earth or sea.

† Mr. Allen states that the form of the cloud and of the cone of vapor depending from it so nearly resembled the engraved pictures of "water-spouts" above the ocean, that he should have come speedily to the conclusion that one of these "water-spouts" was approaching, had he not been aware that "this phenomenon occupied a space in the heavens directly above a dry plain of land." Perhaps it might be inferred that Mr. A. had partaken of the too common notion, that the misnamed *water-spout* is, or should be, literally a *spout of water*. This phenomenon, so much talked of among mariners, proves to be nothing more nor less than the visible, inverted "tapering cone of vapor" or condensation, noticed by him as "extending from the cloud to the surface of the earth," *at the axis or ascending portion of the whirl;* if we may at all rely on the results of extensive examinations and comparisons of the accounts of "water-spouts" and their effects. The same appearance was observed in the New Brunswick

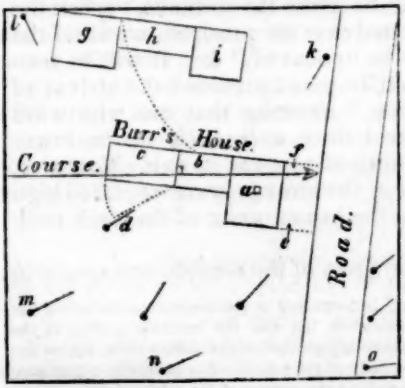
a straight line, following the direction of the wind, with a velocity of perhaps eight or ten miles per hour. Near as I was to the exterior edge of the circle of the tornado, I felt no extraordinary gust of wind; but noticed that the breeze continued to blow uninterruptedly from the same quarter from which it prevailed before the tornado occurred. I also particularly observed that there was no preceptible increase of temperature of the air adjacent to the edge of the whirlwind, which might have caused an ascending current by a rarefaction of a portion of the atmosphere."

Soliciting a careful attention to the observations of Mr. Allen, who is well known for his intelligence and his habits of correct observation, I proceed to give some account of my own examinations of the traces of this tornado.

From a point on the rocky "ledge" north of the turnpike road and nearly three miles westerly from Providence, to the house of John Burr on the Cranston road, a distance of about one and a quarter miles, I found the course of the tornado to have been S. 86° E. by compass, over a plain country. The magnetic variation being here about 8° westerly, makes the true course E. 3° N. From this point to Providence river, a distance of about two miles, the course was five degrees more northerly.

I agree with Dr. Hare that the general effects observed on this track were "quite similar" to those of the New Brunswick tornado; and will give such of my sketches, formerly prepared, as will best illustrate this similarity and the general effects here mentioned.

Fig. 1. *Providence Tornado.**



The annexed is a sketch [Fig. I,] of some of the effects on the farm of Mr. Burr: His house is about one mile and a half from the Providence bridge.

In this figure, *a* represents a wooden dwelling-house of two stories, with chimney at its centre: *b* a dwelling added to *a* and extending to the rear: *c* a lighter building about 16 feet by 30, attached to the rear of *b*: *g* was a large wooden barn: *h* a long building or shed extending from the barn to the carriage-house *i*. The width of the visible track

tornado by experienced seamen navigating the Raritan river, who at once pronounced it to be a water-spout, and took their measures accordingly. It is probable, however, that most of the "water-spouts" noticed at sea, are inferior in size and energy to these destructive tornadoes.

A "water-spout" was seen by Messrs. Tyerman and Bennet near Borabora in the Pacific, which extended nearly horizontally from one cloud to another directly over their heads; and no harm doue! The most credulous will hardly conceive this to have been *a column of water*, or even approximately such; besides, no sea-water has ever been known to fall from the clouds. Similar "spouts" have been seen by others; and I once beheld a magnificent example of this kind, in one of the interior towns of Connecticut; which probably indicated an axis of rotation nearly horizontal.

* On these plans the large dot at the end of the several short lines, shows the original position of the root of the tree; the pointed end of the line shows the direction of its top.

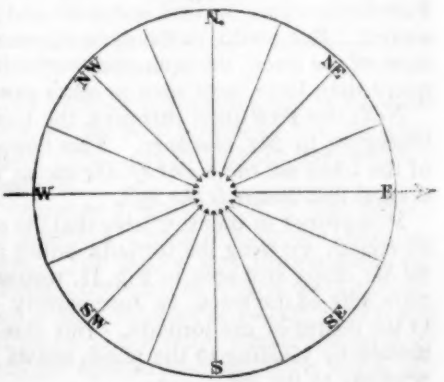
was here about five hundred feet, and the course of the centre or axis of the tornado appeared to have passed somewhat diagonally over the first three named buildings.

The house *a* withstood the shock, receiving some damage; the chimney top of *b* was thrown on the roof of *a*, perforating the same, while *b* was unroofed and greatly injured, and a long timber or *sill* from the shed *h* broke endwise into the upper part of the house *b* from a northwesterly direction. The building *c* was turned more than twenty feet to the *left about*, as regards the axis of the whirlwind, against the top of the prostrated pear tree *d*, and was there overturned upon it. There were twenty-one persons in *a* and *b*, including a school of children, none of whom were seriously injured.

The barn *g* and the shed *h* were destroyed, and the materials swept off toward the first named buildings. A corn-house, standing on the same side with the barn, is stated in the Providence papers to have blown over to the *west*, but I can find no notes of my own respecting the direction of its fall.

The effects here exhibited appear to me to be due to a progressive whirlwind, revolving to the left; for we may notice, as in the New Brunswick tornado, a more onward direction in the trees prostrated on the *right* of the axis, *d*, *m*, *n*, *o*, &c., than on the left side; while the outermost prostrations on the right, *n*, *o*, point still more nearly than the average on this side, to the course of the tornado: And on the left side of the track we have the tree *k* in a direction inclined several degrees *backward* from the course of the storm. The value of these indications of whirling action I have endeavoured to point out in my remarks on the New Brunswick case. [This Journal, vol. ii, 3rd series, 1841, p. 41–48.]

Fig. II.



At the front of the house *a*, however, were two slatted door-yard fences, extending from the house to the road. The fence *e* was overthrown northward towards *f*, and the fence *f* in the contrary direction towards *e*: both directions being *transverse* to the line of the axis, which passes between them. Such cases have been adduced as supporting a directly inward course of the wind in the body of the tornado; or, as indicating two bodies of opposing wind meeting on a central line; but I draw a different conclusion.

Let Fig. II represent, horizontally, the directions of such centre blowing winds in the body of the tornado, and let it be supposed as passing over the area of Fig I, without revolving, so as the course of the centre will coincide with the arrow which indicates the course of

the axis on that figure. It may thus be seen that on this hypothesis the wind must strike the fences *e*, *f*, either parallel to their length, or but little oblique; a direction of wind which seldom or never prostrates fences, even in the path of a tornado. Besides, *near the centre* of such an inward blowing tornado, where only it could act on these fences with *lateral* force, such winds must necessarily become neutralized both by blowing against each other and by turning upward to escape, thus having little effect at this point, within four feet of the ground. I say nothing here of the possibility of any winds blowing *with violence* in such central and opposing directions; which I could never conceive: for the entire spaces between the centripetal lines of arrows must be conceived as being filled by the affluent winds; the lines only indicating their directions.

But on the other hand, let us suppose a strong whirlwind passing in the same direction: the front half of which, both on and near the line pursued by its axis, must necessarily sweep laterally across this line, first *northwardly* towards *f*, if it be revolving to the left; and the last half of the whirl on its arrival will sweep *southwardly* towards *e*; which sufficiently accounts for the effects observed. That only the fence *e* was thus prostrated by the first wind of the tornado may be explained by the protection afforded to *f* by the house, against the *advancing* whirl, and perhaps here, also, by the spirally *upward* tendency towards the centre, in the wind which thus came round the southeast corner of the house, prostrating *e* in its course. But on the passing of the axis of the whirl, the wind would recur with increased force from the opposite direction, upon the fence *f*, prostrating it towards *e*; while the latter, being already down, and in turn partially protected by the house, would remain as it first fell.

In passing over the track of the tornado between Burr's house and Providence river, several instances and groups of prostration were observed. But owing to the open character of the grounds throughout most of the track, the memorials afforded by the trees were less frequent than have been seen in other cases.

Near the Pawtuxet turnpike, the tornado encountered a new house belonging to Mr. Gardner. This house was in the southern portion of the track *on the right of the axis*, and was removed and *turned* several feet *towards the left*.

It is proper to mention here that the *order of changes* in the wind's *direction*, viewing the tornado either as a whirlwind, or, as claimed by Mr. Espy and seen in Fig. II, would at any *fixed point* on this the right side of the track, be successively *towards the right*, as relates to the centre of the tornado. But this building having received its motion by yielding to the wind, shows the true course of the latter as whirling to the left.

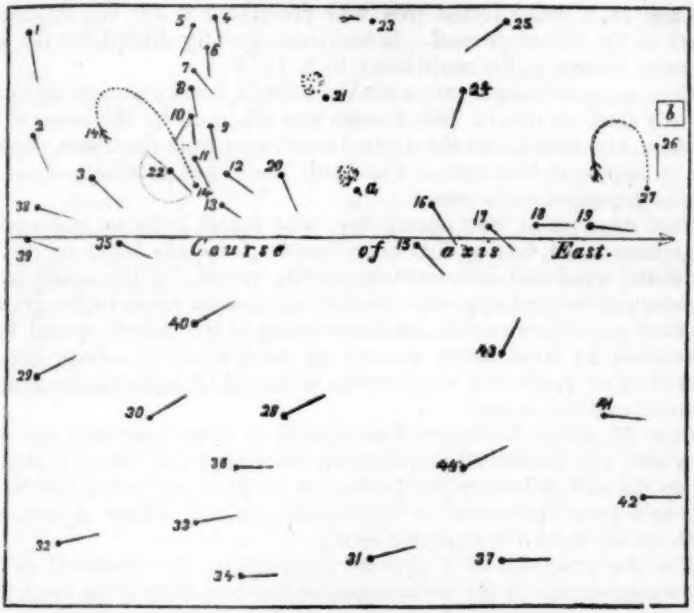
Passing by the prostration of the range of buildings near the river, described by Mr. Allen, I proceed to notice the effects which appeared on crossing to the Massachusetts side.

From the bank of the river to the house of Abraham Tifts on the Lyon farm, three-fourths of a mile, the grounds were open and un-

broken, being mostly under cultivation and with few trees exposed to the tornado, excepting an orchard of scattered apple trees westward of Tifts' house. The traces of the wind in and adjacent to this orchard were very distinct in their character, and I subjoin here the sketch on which they are represented.

Fig. III. *Providence Tornado.*

North or left side.



South or right side.

Explanations of Fig. III.—The cases of prostration 4 to 14, were from a line of small locust trees on the west border of an old apple orchard, and are severally shifted a little out of line for the sake of a distinct exhibition of their directions.

From thence to near Tifts' house at *b*, the ground is but slightly foreshortened, and the relative positions of each tree, on the left of the centre, is approximately shown. The figure was drawn from my field notes on account of the distinct phenomena which were exhibited on this part of the track, and which, in cases *a*, 14, 22, 21, 23, and 27, show conclusively the first action of the whirl *across the path of the axis*, and sweeping towards the northern border of the track. On the opposite or right side of the axis, southward of 15, there were no trees exposed, and the effects of the tornado were here visible only on the crops and fences. Therefore the cases shown on the figure south of the axis, and also westward of 22 on the left hand side, were brought in from the more western parts of the track between the orchard and the river, and include all the prostrations from the latter to Tifts' house;

and their relative distances from the axis or centre of the track are but approximated.

Case 14, represents a small locust tree broken off at an old wound near the root and carried *outward and backward* into the adjoining fallow field, having struck into the ground several times in its course, leaving distinct traces. It was finally left at a point N. 57° W. from its stump, at the distance of forty yards, with its top turned southwardly, in conformity with its two last traces in the soft ground.

Case 10, a small locust tree was prostrated S. 25° W., leaving its mark in the fallow ground. It was subsequently shifted, by the progressive change in the whirlwind, to S. 11° E.

Case *a*, an old apple tree with but a single branch projecting southwardly from its trunk: This branch was taken off by the onset of the tornado, and struck into the ground northwest from the trunk, depositing its apples at this spot. The limb itself was missing.—Case 21, apples deposited as in case *a*.

Case 22, a small wild cherry tree, was found lying on and against the stump of 14, having first been thrown *from the latter* by the onset of the wind and subsequently swung round by the south to its present position, as appeared by the impressions made in the ground. Its final position was such, as if occurring at the outset would have prevented 14 from being carried off northwesterly.—Case 23, the branch of an apple tree was thrown west.—At *b* is shown the relative position of Tifts' house.

Case 27, shows the original position of a large pear tree, the stem of which was broken off and first thrown northward, where it ploughed up the soft ground of the garden by its force, and continued its circuit to a point northwest of its original position, where it remained with its top turned toward the south.

For the purposes of a general comparison, the observed or first known directions of the prostrations on the two sides of the track may be summed up as follows.

Left or North side of the Track.		*Right or South side of the Track.*	
Case.	Direction of first prostration.	Case.	Direction of first prostration.
38	S. 74° E.	29	N. 65° E.
39	S. 70 E.	32	N. 77 E.
35	S. 67 E.	30	N. 60 E.
1	S. 10 E.	33	N. 80 E.
2	S. 23 E.	34	N. 88 E.
3	S. 45 E.	36	East,
4	S. 12 E.	40	N. 65 E.
5	S. 35 W. (backw'd)	28	N. 63 E.
6	S. 5 E.	31	N. 75 E.
7	S. 40 E.	44	N. 63 E.
8	S. 11 E.	37	N. 87 E.
9	S. 10 E.	43	N. 30 E.
10	fell S. 25 W. turned to S. 11 E.	41	S. 85 E.
		42	East,

Left or North side of the Track.	*Right or South side of the Track.*
Inclination inward and backward from course of tornado.	Inclination inward and backward from course of tornado.
16 degr's.	25 degr's.
20	13
23	30
80	10
67	2
45	0
78	25
125	27
85	15
50	27
79	13
80	60
115	5
	0

Case.	Direction of first prostration.	Inclination inward and backward from course of tornado.
11	S. 26° E.	64 degr's.
12	S. 55 E.	35
13	S. 55 E.	35
14	first thrown N. 23 W. (backward)	247
15	S. 45 E.	45
16	S. 30 E.	60
17	S. 55 E.	35
18	East,	0
19	S. 85 E.	5
20	S. 27 E.	63
21	N. 55 W. (backw'd)	215
22	first fell N. W. turned to S. 37 E.	225
a	N. 45 W. (backw'd)	225
23	Branch of apple tree thown west	183
24	S. 20 W. (backw'd)	110
25	S. 55 W. (backw'd)	145
26	South,	90
27	first thrown N. 10 W.	260

Mean direction of prostration on the right side of the track N. 73° E.: average inclination inward from course of tornado, *seventeen degrees.*

Mean direction of first prostrations on the *left side* of track, S. 4° W.: average inclination inward and backward from course of tornado, *ninety-four degrees.*

Relative inclinations of the two sides to the line of axis, more than *five* to *one.*

It is proper to mention, that the average inward inclination of *all* the prostrations on the *right* side of the track for a distance of four miles east of the river was thirty degrees.* This, however, does not affect the conclusions in favor of rotation to the left.

These average results, on the two sides, together with the several particular observations already adduced, appear to me to afford decisive evidence of whirlwind rotation in this tornado, in the direction from right to left or which is contrary to the hands of a watch. In reference to this evidence and that exhibited in my paper on the New Brunswick tornado, I add from my prepared sketches the following figure, as an approximate illustration of the whirling action in these tornadoes, so far as this may be shown *horizontally* and by a stationary figure.

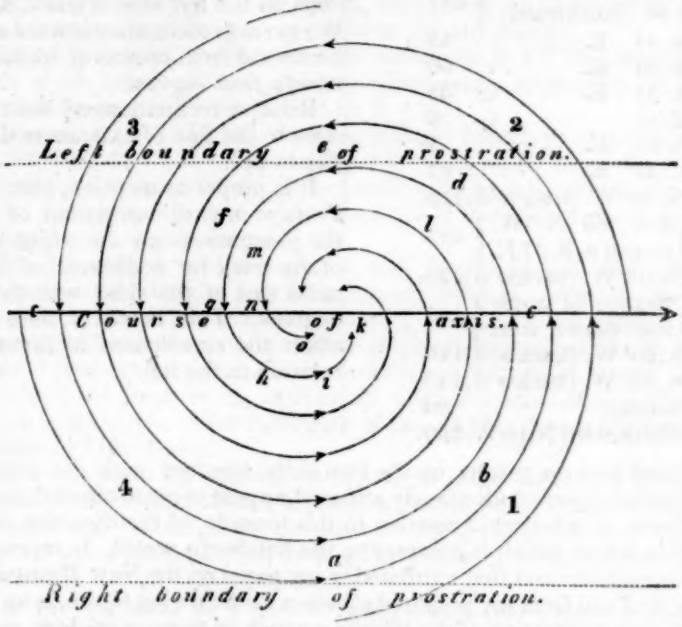
Let the involuted lines or arrows on figure IV be supposed to represent the motion of the wind at or near the bottom of a vertically cylindrical portion of the centre of a tornado, comprising a length of radius equal to the greatest width of the prostrating power on the right of the axis of its path. Now if the tornado be considered as whirling in the manner here represented, but *without any change of location*, its action may be supposed as concentrically equal on all sides; the motion, however, becoming quickened towards the centre in the *inverse ratio* of the successive concentric areas: that is, each particle of air as it revolves about the axis, *continuing to describe nearly equal areas in equal times*, in its progress towards the centre, where it rises spirally in the direction of discharge; this direction being vertically at the centre, the point or area of least atmospheric resistance or pressure. Thus, the course of a single particle, horizontally, may be *a b*

* This larger average gives a relative degree of inclination on the two sides of *three* to *one*. Nearly the same difference is found in two outside bands of prostration, of equal widths, (Tables I and V,) shown in my survey of the New Brunswick Tornado. See this Journal, vol. ii, 3rd series, 1841, p. 44.

c d e f g h i k;—and so on or between each of the four involuted lines which constitute the figure.

For further reference, we may divide this figure by the cross lines of arrow heads, into the four quadrants 1, 2, 3, 4.

Fig. IV.



We will now consider this whirl as having *a constant progressive motion* on the line of the long arrow *c c*, at a rate equal to one-fourth or fifth of its average rotative velocity. It will then follow, that as the force of the whirl on the trees and other objects encountered by it, is *as the square of the wind's velocity* at the point of impingement, the relative effects on the two sides of the line of the axis, which before were equal, will now be greatly altered.

For, if at a given distance *on the right* of the advancing axis, the former velocity was 80, it will now, as relates to the earth's surface, have become 100; and at the same distance on the *left* side the velocity of the wind will be reduced to 60, as relates to the earth's surface. Thus the squares of these effective velocities will give a power relatively equal to 100 at the former point and only 36 at the latter; both being equally distant from the axis. Hence, although the *rotative* velocity of the whirl decreases rapidly as we recede from its axis, yet its *prostrating* power will, by its progressive motion, become greatly extended on the *right* side of the advancing axis, and proportionally contracted on the left side. Thus the respective boundaries of the prostrating power on the two sides of the tornado, when thus in mo-

tion, may be those indicated on the figure; which nearly correspond to the effects which have been observed in several cases.

It may be seen further, that *nearly all the prostrations* near the line of the axis and elsewhere, must by the advancing motion of the tornado, receive a direction *more onward* than is represented by the arrows or lines in the figure, which can represent only a stationary rotation.

In further considering these effects, in different portions of the whirl, as it encounters objects in its advance, we shall find the maximum effects to be mainly on the line *a, i, o,* at the rear of the *first quadrant.* Hence, if a tree on this side the axis should fail to be prostrated till after the first quadrant had passed over, it would not be likely to fall in the fourth quadrant, on the further advance of the tornado, unless very near to its axis. Moreover, if one tree should fall when under the more advanced portion of the first quadrant, another if prostrated later in the same quadrant, must necessarily fall in a *more onward* direction than the first, and if sufficiently near will lie across the latter.

It may likewise be seen, that the wind of the whirl in passing into the *second quadrant,* on the left side of the track, is sweeping *backward,* and with its effective power thus greatly reduced, as regards fixed objects on the earth's surface. Thus the limits of prostration are not only narrowed, but the effective power is here greatly reduced, and gives *fewer prostrations* than under either the first or third quadrants. The *minimum* of effect occurs on the arrival of the line *e k,* at the rear of the second quadrant.

But on the arrival of the *third quadrant,* the prostrating power on the left side becomes more and more efficient by the ceasing of the backward and the accession of the progressive movement; and at or near the line of *f m,* it again takes effect, with rapid increase. The destructive force is also much augmented here by the greater velocity in the heart of the whirl, near its axis, and the impetus must rapidly increase in energy to its maximum effect, as at *m n o,* taking off any tree which may here remain, and carrying aloft, or sweeping onward, the objects previously prostrated on the line *c x k.*

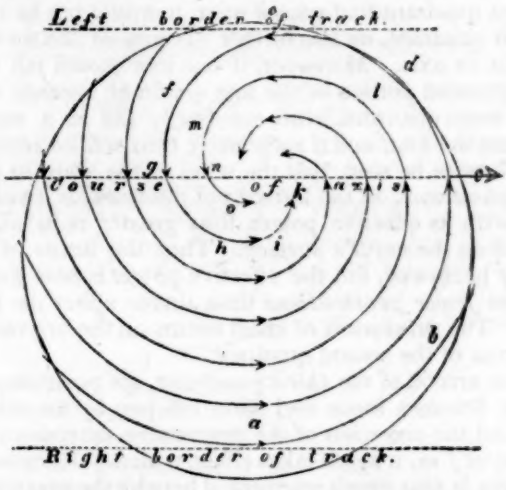
If a tree on the *left* side of the track falls on one previously thrown down by the tornado, the last fallen will also have the more onward direction, as on the other side: unless both have fallen in the second quadrant, where few prostrations occur. The *fourth quadrant,* for causes noticed in considering the *first,* can have little prostrating effect; except perhaps on the small area near its axis.

If we now conceive of our figure as applied only to the limits of prostration or destruction which constitute the *visible path* of the tornado, it becomes apparently and relatively unequal, in its right and left hand quadrants, the axis appearing greatly eccentric, and in the same degree, at least, as the *left* band or belt of prostrations is found narrower than that on the right of the axis. This apparent, but illusive form of the whirl, may be illustrated by Fig. V, which is drawn on the same lines with the preceding figure.

It will readily be seen that this eccentricity of the axis, on the visible track, will be in proportion to *the progressive velocity of the tornado;* other things being equal. Thus, if Mr. Allen be nearly right

in his estimate of the rate of progress in the Providence tornado, the eccentricity shown in its path would be generally less than is shown in figures IV and V. On the other hand, if the progressive velocity should be as great as Professor Loomis informs me he ascribes to the tornado of February last, in Ohio, viz. about forty miles an hour, the eccentricity would in such a case be greatly increased, showing the axis as far outward, perhaps, as would be in line with *m*, or *f l*, in these two figures.

Fig. V.



From this examination it appears to result, that an observer who follows the track of a tornado after its departure, will find on one side of the apparent axis of its path, *if it be a whirlwind*, a continued series of prostrations pointing almost invariably onward and inward, with various degrees of inclination to the course of the path. While on the other side of the axis, a narrower band or belt of prostrations will be found, which are also inclined mainly inward and onward, but showing greater inclinations from the line of progress, together with frequent cases which incline more or less backward and sometimes even outward from the course of the tornado.

It may also appear, that a want of proper attention to the necessary conditions of the prostrating power in a progressive whirlwind, can alone induce us to ascribe such effects to supposed antagonistic winds, blowing simultaneously in opposing directions.

Leaving, for a moment, the more tangible features of this inquiry, we may now take some notice of the more outward portions of the "cone" or whirlwind, which are supposed not to be comprised in Fig. IV. Assuming here the involuted and inward motion, with its upward discharge at the centre, it follows that the impulsive accession of air which is necessary for maintaining a violent whirlwind action, must come in horizontally, and in the same gradually involuted courses;

or, must descend in like manner from a higher region, in and around the outward parts of the whirling cone. I have long since been led to believe that this impulsive accession comes from *both* these sources, but *chiefly from the latter;* and that this motion of accession and support is spirally *downward* in the outward portions of the whirl. The latter being, in its higher portions, often greatly expanded, as noticed by Mr. Allen.

The evidence on which this opinion rests, can be but partially alluded to here; but I will suggest the following considerations:—1. The ascertained existence of a stratum of unusually cold air in the higher region of clouds, on some particular days remarkable for the occurrence of numerous thunder gusts and tornadoes.* 2. The observed descent of a portion of the clouds in front of the nucleus or body of a heavy squall, or tornado, which may sometimes be traced by the eye as low as the existing limit of condensation will afford opportunity for observation. 3. The fact noticed by Mr. Allen and others, that adjacent "to the exterior edge of the circle of the tornado" or whirlwind, the previous breeze often continues "to blow uninterruptedly from the same quarter" as before.† 4. The last fact, when taken also in connexion with certain peculiar and striking effects in the outward portions or edge of the tornado, a knowledge of which I have gathered from various sources. 5. The coldness of the air which has been noticed at the edge of a whirlwind. 6. The instant penetration of the lower end of the whirlwind into thick forests, and into hollows and ravines, which has been frequently noticed. 7. The direct memorials of downward action in the outward portions of the whirl, which I have myself met with, on the tracks of different tornadoes.

In most of the foregoing remarks it has been my design to view the tornado as it moves onward, in full action. Of the origin or incipient causes of the whirl, it is not necessary here to inquire; although some clue to these is perhaps afforded us in the considerations above noticed.

Recurring once more to the track of the Providence tornado, I have to state that eastward of Tifts' house the course of the track soon became S. 65° E. magnetic, for more than two miles. It then took the course of S. 75° E., and further onward the tornado passed directly over the house of Solomon Peck, about four miles from Providence. This house was partly unroofed; chimney thrown down; windows broken *inward*, as in many other cases; and much other damage was also done to Mr. Peck's property. In passing onward towards Taunton river the tornado appears to have preserved an inclination to the south of east: the track, though slightly sinuous, appearing, like that

* This change of upper temperature I think can be clearly made out on the day of the New Brunwick tornado, which was but one of many tornadoes and thunder gusts which appeared in this part of the United States on the same day; and on the preceding day in Illinois and other western states.

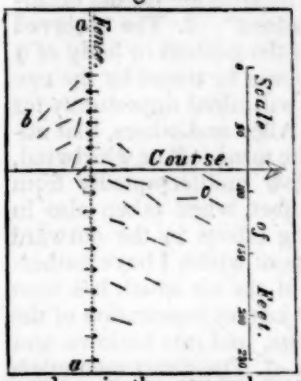
In the New Haven Gazette are accounts of *five* severe tornadoes which occurred in the states of New Jersey, Connecticut, Massachusetts and Rhode Island, on the afternoon of August 15, 1787. I can also refer to many more recent cases of this kind.

† The observation here quoted is one of many which show the error of the very hasty generalization which alleges a circuit or annulus of calm air to have been observed *on all sides* of tornadoes and hurricanes.

of the New Brunswick tornado, to form part of a great curve, with its convex side to the northward.

On the track from the Lyon farm to Peck's house there were many interesting memorials which might confirm the deductions already made. On some portions of the track, also, the tornado appeared to have risen almost entirely from the surface, its reverse apex leaving but a narrow trace, and on some fields, even no trace at all. But in these cases, as on the tracks of other tornadoes, the compass bearing did not fail to lead the explorer to new ravages, where, at times, the energy of the tornado appeared to be greater than before.*

Fig. VI.



Before we take leave of the traces of this tornado I would adduce another of my prepared sketches, which shows the rotative effects in a manner which I think should satisfy the most strenuous opposer of whirlwind action. In this sketch, Fig. VI, we have represented a portion of the track which crossed at right angles a line of weak post-and-rail fence, *a*, *a*. On the *right* of the axis, this fence was prostrated *eastwardly* or in the direction of the course of the tornado, as shown by the short arrows which may represent the posts of the fence; the rails also having been scattered onward and inward, towards *c*, in the general manner represented in the figure. On the *left* side, however, every post was prostrated *westwardly*, and the rails were likewise blown slightly backward toward *b*, in the same general direction. The scale of feet, which measures across the track, was obtained by estimating twelve feet to each length of the rails. The locality of this sketch was, perhaps, a mile eastward of the Lyon farm.

The application of the foregoing views of rotation to this case, it can hardly be necessary to point out.

I have noticed many effects of similar kind on fences; but that the *backward* prostration on the left side of the track should have taken full effect in this case, and mainly, perhaps, under the second quadrant, I ascribe to the age and general weakness of the fence.

Additional memorials might here be adduced in evidence, and of similar character to the foregoing; but having already occupied more space than I intended, I must now leave the question of a general whirlwind rotation in this and other tornadoes to the candid consideration of impartial inquirers.

New York, July 12, 1842.

* This is not uncommon in tornadoes, and is especially noticed in the account of two "Trombes" which are given in Pouillet, Elemens de Physique et de Météorologie, § 655.

Mechanics' Register.

LIST OF AMERICAN PATENTS WHICH ISSUED IN AUGUST, 1841.

With Remarks and Exemplifications by the Editor.

1. For an improvement in the Process of *Distilling;* Samuel Oliver, Northampton county, Pennsylvania, August 4.

This improvement, the patentee says, "consists in the introduction of wood ashes, lye, or potash, or either of them, into combination with the rye, corn, or other grain, after it has been mashed, and before the process of fermentation commences, and mixing it with the same in the proper proportions."

Claim.—"What I claim as my invention, discovery and improvement, and desire to secure by letters patent is, the application of wood ashes, lye, or potash, to the process of distillation of rye, corn, or other grain into whiskey, or alcohol, for the purpose of retarding the acetous fermentation and increasing the yield, using the specified quantities, or increasing or diminishing them as circumstances may require."

2. For an improvement in the Handles or Tholes of *Scythe Snaths;* Selah W. Fox and Arestes Terry, Bernardstown, Franklin county, Massachusetts, August 4.

Claim.—"We claim as our invention, constructing the clamp ring of the tholes with a spring washer on the interior of the same, and combining the said clamp ring with a shank firmly fixed in the handles, and having a male screw at one end which engages with a corresponding female screw in the lower and conical shaped part of the clamp ring, the whole being constructed and operating together in the manner described and for the purpose of firmly confining the handle to the snath. We also claim forming the shank which is inserted in the wooden handle, with a shoulder, by means of which the shoulder operates to press the collar against the snath, and draws the clamp ring down upon the opposite side of the same, independent of the wooden part of the handle, the whole being for the purpose specified."

3. For an improvement in the Process of *Hardening Steel;* Perry Davis, Fall River, Bristol county, Massachusetts, August 4.

The method of hardening steel as practiced by the patentee is as follows. "Instead of plunging the steel to be hardened into cold water, as is usual, it is plunged into a composition of borax, oil, and charcoal, to harden it, which mode of hardening renders the metal malleable with the same degree of hardness that was obtained by the old method; so that the metal, after being hardened in this way can be straightened or bent without any danger of being broken."

Claim.—"What I claim as my invention and which I desire to secure by letters patent is the mode of hardening steel so as to render it flexible by means of the composition of oil, charcoal, and borax, as set forth."

What influence the above described mixture can exert upon the part to be hardened, we are at a loss to perceive, and apprehend that the method frequently practiced of using oil alone, would have the same effect with the compound above indicated. We have been in the habit of hardening steel, and know of many devices which have been resorted to for the purpose of communicating toughness, but believe them all to be founded in error. The less rapid the cooling, the less will be the hardness, and, of course, the greater the toughness of the article operated upon.

---

4. For an improvement in *Propelling Boats;* Meredith Mallary, Urbanna, Steuben county, New York, August 4.

There is to be a common water wheel, such as is used for driving mills, on each side of the vessel, or boat, immediately in the rear of the ordinary paddle wheel, and the shafts of the two sets of wheels are to be geared together; the water which is thrown up by the common paddle wheels is to fall into the buckets of the water wheels, and is there to lend its aid in the business of propelling.

Claim.—"Now what I claim as my invention is the applying the water lifted or thrown up by the paddle wheels of steam boats so as to produce an auxiliary propelling power, in the manner described, or in any way analogous thereto."

That these auxiliary wheels will exert some influence we have no doubt, but we are much mistaken if they do not prove to belong to the class of consumers only, and that of the worst kind, as they will not pay for what they devour.

---

5. For an Ornamental *Covering for Stove Pipe Flues;* Perry Davis, Fall River, Bristol county, Massachusetts, August 4.

A plate is to be attached to a wall, where a stove pipe is to be inserted, with a hole in it to receive the end of such pipe, and a thin plate moving in suitable grooves, is to slide over and cover the hole, for the stove pipe, during summer when the stove is taken down.

Claim.—"I do not claim as my invention the construction of a plate with an aperture for stove pipes, having a slide to cover said aperture; but what I do claim as my invention and which I desire to secure by letters patent is constructing the perforated plate with a collar around the aperture to adapt it to the hole made by the stove pipe, in combination with the slide covering said aperture, as set forth."

In the whole catalogue of things patented we recollect but few so little worthy of the broad seal as the foregoing, and we are truly at a loss to perceive by what kind of logic it can be made to appear that a sliding cover to a stove pipe hole is a new and useful invention. There must have been some singular oversight, or obliquity of vision,

when a patent was ordered to issue for such a common and valueless device.

---

6. For improvements in the *Condenser and Apparatus for Supplying Steam Boilers;* Joseph Echols, Columbus, Muscogee county, Georgia, August 11.

The apparatus, as described, for supplying boilers, consists of a receptacle, communicating with a cistern and with the boiler, by means of pipes governed by a four way cock which alternately forms a connection with the cistern, from which to receive the water, and then with the boiler to supply it with the water, thus received. The pipes forming these connections are narrow and high, and the one leading to the boiler has an inclination towards, and opens into, it, above the water line. Thus, when the communication between the boiler and receptacle is open, the steam from the former passes into the latter, and from this the water runs down the lower inclined surface of the tube into the former. The cock being then turned, cuts off this communication and opens it with the reservoir, which allows the water to run into the receptacle and condense the steam by which the water was expelled in the previous part of the operation. For low pressure engines, it is said that the top of the reservoir must be closed and a connection formed between it and the condenser.

The condenser is divided into two compartments, separated by a diaphragm pierced with small holes, and this forms a connection with a cistern of cold water by means of a fourway cock and receptacle such as are employed in the apparatus for supplying water, and operates in the same manner. The condenser is also connected with the cylinder of the engine, and is provided with an aperture and valve for the discharge of air and water. The water after passing from the cistern into the receptacle escapes into the upper division of the condenser, and percolating through the perforations in the diaphragm, condenses the steam. The air is forced from the condenser into the receptacle by the entering water, and in the same manner from the receptacle into the cistern.

Claim.—"What I claim and desire to secure by letters patent is, first, the manner in which I have combined and arranged the said cistern, receptacle, the said four-way cock, and the boiler, with said respective water passages, so as to effect the object of dispensing with force pumps (now in use for supplying boilers) and of giving a regular supply of water to the boiler, and of maintaining it at the same and desired height at all times, as above set forth. I do not claim the use of a four-way cock (except so far as using the plug of the same with only one passage through it) or of any of the respective parts of this apparatus taken individually, but I do claim them collectively in the particular combination described, not intending by this claim to limit myself to the exact form and manner of constructing the respective parts aforesaid, but to vary them as I may find expedient while they remain substantially the same, as herein before set forth. Secondly, I claim the manner in which I have combined and arranged the fore-

going described apparatus for condensing steam and for discharging a portion of the air liberated therefrom without the employment of an air pump. That is to say, I claim the manner in which I have combined and arranged the cold water cistern, the steam receiver or condenser, the receptacle and the four-way cock, so as effect the condensation of steam and of discharging a portion, at least, and in some situations nearly all, the air from said receiver or condenser through the said receptacle and cock substantially as herein described."

---

7. For an improvement in the manner of constructing *Furnaces for Warming Apartments,* and for Cooking; William A. Shepherd, Waterville, Kennebec county, Maine, August 11.

Claim.—"What I claim as my invention is the manner set forth of arranging an air heating and cooking apparatus, by surrounding the interior of an air heating stove, by ranges of tubes, within which the air is to be heated, and thence conveyed so as to pass around an oven, or other cooking instrument, and subsequently into any apartment where heated air is required." The particular arrangement of this apparatus could not readily be made known without a drawing, and this we do not think it worth while to give.

---

8. For an improvement in *Cabooses or Cooking Stoves;* Loftis Wood, New York city, August 11.

In this stove there are two ovens, between and towards the upper part of which is the fire chamber, with an ash pit below. The grate bars below the fire are made hollow and open into each of the ovens, the side plate of each oven, towards the fire chamber, being pierced to receive each grate bar. The bars are pierced with holes on their under sides to receive air from the ash pit, which passes through them, and enters the ovens highly heated.

The bottom plates of the ovens are made to lift out, to give free admission to the flues beneath them. There is above this bottom plate a sliding, or false, bottom, which is usually made of open work, and has a rack on the underside into which a pinion works, for the purpose of sliding this false bottom in and out, together with the articles upon it which are to be baked.

Claim.—"What I claim therein as new, and desire to secure by letters patent, is the manner of combining the two ovens, the fire chamber between them, and the hollow grate bars, through each of which a current of heated air is admitted into each of the ovens, in the manner described. I also claim the false, or sliding, oven bottoms, having racks on their lower sides into which pinions mash, by which said bottoms are to be moved in and out by a combination and arrangement of parts, as set forth."

---

9. For an improvement in the *Wind Mill;* Perry Davis, Fall River, Bristol county, Massachusetts, August 11.

This patent is taken for a modification of the ordinary vertical wind

mill, with inclined sails, or vanes. The shaft of the wind wheel has its bearings in the upper part of a tower, which rests, and turns, on a circular railway, and on a hollow shaft attached to the main framing. A solid shaft passes through the hollow shaft of the tower and is made to revolve by a crown wheel on the shaft of the wind wheel; and from its lower end motion is communicated to any kind of machinery to be driven. The lower inner edge of the tower is provided with cogs into which the teeth of a pinion, on the end of a vertical shaft, take for the purpose of turning it. This last mentioned shaft is connected with a centrifugal regulator, or governor, the balls of which are operated on by a sliding clutch that clutches either of two bevel pinions on its shaft so that when the mill runs too fast the balls are thrown out so far as to clutch the upper wheel, and thus to turn the tower, and the wind wheel, from the wind; and when it runs too slowly, the balls fall, and clutch the lower wheel which turns the wind wheel to the wind.

Claim.—"What I claim as my invention, and which I desire to secure by letters patent is, the manner in which the movable tower is combined with the hollow stationary shaft, and main shaft of the machine, by making the hollow shaft stationary upon the frame as set forth, and causing the tower to revolve upon it, and combining the main shaft with the above arrangement by passing it through the hollow shaft in the manner described."

The second section of the claim is omitted, as it refers to, and would not be understood, without the drawings; it is, however, confined to the mode of regulating the position of the wheel in relation to the wind by means of the slide and clutch attached to the arms of the regulator, and clutching alternately the upper and lower wheels in combination with the cog rim on the tower.

---

10. For an improvement in the *Cooking Stove;* Samuel L. Chase, Woodstock, Windsor county, Vermont, August 11.

The patent of which this is a reissue, was granted on the 25th of September, 1840, and is noticed in vol. ii of the third series of this Journal, page 345, to which the reader is referred for an explanation of its general characteristics. By comparing the following claim of the amended specification with the original, the reader will perceive the emendations which have been made in the patent.

Claim.—"Having thus fully described the nature of my improvement, and shown how the same is carried into operation, and having in so doing shown and described many parts and devices, of which I do not claim to be the inventor, I now proceed to state what I do claim, and desire to secure by letters patent, viz., first, the manner in which I have combined and arranged the flues, including the rarefier, as set forth, that is to say, the admitting the heated air from the fire chamber into the flue between the upper and the lower ovens; conducting it thence through the flue at one end of the flue under the lower oven, thence into the rarefying flue under the fire chamber, and thence into the exit pipe, all substantially as herein made known, and represented. Secondly, I claim, in combination, the arrangement

of the respective parts of the hearth for broiling, and other cooking operations, which arrangement consists of the sunken hearth, furnished with the bars and openings for the admission of air, the swinging hearth, and the flue formed by the notch in said hearth, and the sloping projection at the lower edge of the furnace door, or on the swinging hearth. I also claim the swinging hearth in combination with the sunken hearth, whether the said swinging hearth be made in one or in two parts, such swinging hearth constituting, when closed, the top or cover of the sunk hearth, and being provided with boiler holes and otherwise constructed and arranged as set forth."

---

11. For improvements in the *Cooking Stove* invented by Samuel L. Chase, Woodstock, Windsor county, Vermont, August 11.

This patent is for improvements in the stove noticed in the foregoing article, and, in the improved form, the sunk hearth, which is covered by the swinging hearth, is provided with grate bars near the bottom and the whole space is divided into two compartments by a partition, above and below the grate. A small draught hole is provided at each end. There are two ovens in this stove, one above the other, and back of the fire chamber, the flues passing over, under, and up the ends of each. There is one draught hole that enters from the fire chamber into the flue under the bottom of the lower oven, the draught dividing and passing up the two side flues, and over the top oven to the exit pipe, and three other draught holes that enter from the upper part of the fire chamber into the flue between the two ovens, the two outside ones opening partly into the vertical side flues, and being provided with dampers to regulate the draught.

Claim.—"What I claim is, first, the dividing the sunken hearth into two compartments, below the grate bars, in combination with a stove having a swinging hearth, and a draught space below the projections on said swinging hearth, in the manner and for the purpose described. I also claim the manner in which I have arranged and combined the flues, and the four spaces, or openings, leading into them from the fire chamber; the whole being constructed, governed, and operating as set forth."

---

12. For a Locomotive *Battery for Harbor Defence;* Prosper Martin, Philadelphia, Pennsylvania, August 11.

The patentee proposes to make use of common steamboats in time of war for the defence of harbors, &c., by surrounding them with double or single floating batteries which are to form a hollow square. These batteries are to consist of two parts, which may be separated to receive the boat, or boats, and are then to be brought together and made fast.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the conversion of our common steamboats into locomotive batteries, for the protection of our harbors, cities, villages, &c., by securing the steamboats, in part or in whole, in an encasement,

single or double, sufficient to protect them from injury, in manner substantially as herein described."

---

13. For an improvement in *Stoves;* Thomas M. Jones, Boston, Massachusetts, now residing near Birmingham, England, August 11.

The improved stove is represented as being made cylindrical, and having a cylindrical case, or cap, surrounding and revolving on it, and resting on a ledge or flanch projecting all around the body of the stove at any height below the fire chamber. Instead of a door for supplying the fuel, a hole of sufficient size is cut in the body, or cylinder, of the stove, and through the outer casing, so that by revolving one on the other the opening in the body of the stove may be opened or closed at pleasure.

Claim.—"What I claim as my invention is a stove without doors having an internal vessel with a lateral opening for the admission of fuel connected with a movable or revolving external case that covers the whole, or any required portion, of the internal vessel—which external case has a lateral aperture corresponding to that of the inner vessel and is so adjustable that as it revolves more or less it may shut off either the whole, or none, or any part, of the lateral opening of the internal vessel."

---

14. For a method of *Attaching Buttons to Garments;* Henry S. Poole, Boston, Massachusetts, August 11.

In the first place a metallic eyelet is made fast to the cloth in the usual way, and the button, which is made with a hollow cylindrical metallic shank, is rivetted on to the eyelet by means of a punch.

Claim.—"I claim as my improvement and ask a patent for the mode of fastening the button to the cloth by means of a metallic rivet attached to the shank of the button and fastened on a metallic, or other, eyelet, as set forth."

---

15. For an improvement in the *Smut Machine* for Cleaning Grain; Jonas Nolt, West Hempfield township, Lancaster county, Pennsylvania, August 11.

The grain to be cleaned is to fall from the hopper into a shoe from which it is discharged on to a fall board, that is suspended by straps in an inclined position, its lowermost part being one of its corners; and the corner nearest the opening of the shoe where the grain is discharged on to it, being the next highest. The wind board of the fan, which is of the usual construction, directs the wind at an inclination downwards, so as to impinge upon the fall board a little within the lowest edge, the design of which is that as the heavy grains of wheat are rolling towards the lowest corner, the light smut balls may be blown off over the upper edge of the board. The shoe and the fall board receive a shaking motion in the usual manner of shaking the shoe of winnowing mills.

Claim.—"What I claim as my invention, and desire to secure by

letters patent, is the manner in which the fall board, the hopper, the shoe, and the board for directing the current of air upon the grain are combined together—that is to say, the arranging the hopper and shoe over the lower end of the wind board, and inclining the fall board on its inner side and one end so as to allow the grain to cross the current of air, the whole being constructed and operating substantially as set forth."

---

16. For an improvement in the machine for *Cleaning Rice;* Daniel H. Southworth, Little Falls, Herkimer county, New York, Aug. 12.

A patent was granted to Mr. Southworth on the 23rd of August, 1838, for a rice cleaning machine, and is noticed in vol. xxiv of this journal, second series, page 93, to which patent the present improvement is added.

In the original machine, at the upper end of the revolving beaters there was a cast iron conical rubber, which, in connexion with the outer case, rubbed the grain before it passed down to be acted upon by the beaters, and in the present improved form this conical rubber is covered with card teeth.

Claim.—"What I claim as new and desire to secure by letters patent is the employment of a conical rubber of card teeth, or elastic wire points, in the place of my cast iron conical rubber, as described in my original patent; and this I claim whether said card teeth, or elastic wire points, be made to act upon the grain against the rough interior of the outer cone, or shell, or against the same part lined with wire teeth, or points, as set forth."

---

17. For improvements in the *Hydrostatic Press for Pressing Cotton, &c.;* John Houpt, Forkland, Green county, Alabama, Aug. 21.

The follower of this press is below the bed, hence, in the operation of pressing, it is forced upwards; and to insure its parallelism with the bed during its action, there is a connecting rod, jointed at each end of it, which rods extends upwards and are jointed to the ends of two levers, which two levers have their fulcra in the cap of the press, their inner ends being connected together by a jointed link.

The second improvement is in the employing of an air vessel with a large force pump to be used in the commencement of the operation of pressing, and before great force is required; the latter part of the pressing is to be effected with a small pump without the air vessel.

Claim.—"What I claim is, first, the manner of combining the follower of the press with its head, or cap piece, by means of two lever beams, and their connecting rods, arranged and operating in the manner, and for the purpose, set forth; and, secondly, I claim the combining with the force pump of the hydrostatic press an air chamber, the air in which shall be compressed in proportion to the force with which the press is operating, and in such manner as that it shall, by its reaction, gradually diminish the quantity of water raised from the reservoir and thus graduate the action preparatory to the operation of a smaller or more powerful force pump, as herein made known."

18. For an improvement in *Mill Stones;* Pendleton Cheek, Flat Rock, Henry county, Georgia, August 21.

The improved mill stones are to have furrows cut on their faces of sufficient depth to admit of a free current of air, to keep the flour or meal cool; this constitutes the whole novelty, if novelty it be.

Claim.—"What I claim as my invention and desire to secure by letters patent, is the cutting of ventiducts, or ventilators, in mill stones, which will admit the free circulation of the air between the runner and bed stone, thereby keeping them cool and free from heating, burning, or killing the meal or flour in the act of grinding, using for that purpose any ventiducts, ventilators, or narrow deep furrows, as described."

---

19. For an improvement in *Venetian Shutters or Blinds;* John Hampson, New Orleans, Louisiana, August 21.

The device which is the subject of this patent is intended to regulate the turning of the slats of the blind; to retain them in any position, and to prevent them from rattling when used in carriages, railroad cars, &c.

In the grooved cheeks which receive the ends of the slats, there is arranged a set of springs which press a narrow strip against the ends of the slats and thus keep them in place.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the method herein described of preventing the slats from rattling, and retaining them in any position in which they are placed by means of the movable strip pressed up by springs, or other other elastic substance, as described."

---

20. For an improvement on the *Steelyard;* Eli Willemin, Leesburg, Carroll county, Ohio, August 21.

The fulcrum pins, or knife edges, that receive the loops of the hooks, in the improved instrument, are attached to rings that turn on the steelyard, or lever, instead of being attached to the steelyard itself. These rings are retained in their places lengthwise by means of flanches, or other known means. Instead of being made flat and having only one or two edges notched and graduated to receive weights, as in the common steelyard, this instrument is to be made square, and is graduated and notched on three sides to receive the weights, by which the capacity of the apparatus is increased; either of the notched angles may be turned uppermost.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the application of revolving fulcrums to steelyards and balances, by means of which the same steelyard, or balance, may be made to weigh any quantity small or great."

21. For an improvement in the machine for *Raising and Moving Buildings;* Lewis Pullman, Portland, Chatauque county, New York, August 21.

The trucks which are to be employed for removing houses are to consist of an axle having a bolster provided with a pivot, on which the body to be moved rests, the trucks are to be furnished with holes, or mortises, in their peripheries to receive hand spikes by which they are to be turned. The apparatus for raising a building, &c., consists of a frame in which there is a screw that works a sliding nut, and from this nut are suspended hooks to catch on to the lower part of the house.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the combination of the pivot and bolster referred to, with the truck employed, for removing buildings and other weights, consisting of an axle and wheels having mortises on their peripheries to which levers are adapted for moving them. Also in combination with said truck, the screw having a movable nut, with hooks attached to it, for raising buildings, as described."

---

22. For an improvement in the *Moulds for pressing Glass;* Hiram Dillaway, Boston, Massachusetts, August 21.

This improvement in the mode of pressing glass consists in making that part of the mould, or moulds, which forms the inside of the mould, to communicate with a reservoir containing a large body of the melted glass, so that the pressure shall be applied to the said large mass.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the formation of the mould for pressing glass in such a manner that the hollow form, or forms, into which the articles to be manufactured or pressed shall communicate with a larger fountain filled with melted glass, so that the forms may be filled by pressure applied to the mass of melted glass in the fountain."

---

23. For improvements in the *Cut-off Valves of Steam Engines;* Horatio Allen, New York city, August 21.

The patent here named was granted for improvements on the cut-off valves patented by Isaac Adams, on the 17th of May, 1838, and noticed in this journal, vol. xxiii, second series, page 237, to which the reader is referred for a description of the original; which will enable him fully to understand the following claims, viz.

"What I claim in a patent for an adjustable cut-off is as follows: 1st. I claim the combination of two independent cut-off slides, adjustable on the same rod, to be used instead of the single cut-off slide as employed in the combination patented by Isaac Adams, May, 1838, the two acting on top of the slide valve with apertures, as described in said patent, but I do not claim the slide valve with apertures; and consequently this part of my adjustable cut-off, is for an improvement on Adams' cut-off, whereby his cut-off is made an *adjustable cut-off.*

"2nd. I claim the arrangement herein denominated cut-off, with fixed

seats and adjustable slides wherein two independent cut-off slides are combined with two fixed seats, one for each end of the cylinder, and each containing an opening for the passage of steam to its respective end; said slides being adjustable on the rod carrying them, and driven by an eccentric, or cam, on the engine shaft, or by the reciprocating motion of the cross head suitably reduced, all as described.

"3rd. I claim the manner in which the two cut-off slides are made simultaneously adjustable by means of right and left hand screws on the rod carrying them, as described.

"4th. I claim the arrangement and combination for turning the rod carrying the slides, by means of a nut, or cog wheel, through the axle of which the rod passes, and is free to have a reciprocating motion lengthwise, but with which the rod must turn when the nut, or wheel, is turned, as described.

"5th. I claim the arrangement herein denominated "cut-off with adjustable seats," wherein a cut-off slide, or two cut-off slides, on the same rod are combined with two adjustable seats, one for each end of the cylinder, and each containing an opening for the passage of steam to its respective end. The cut-off slide, or slides, being permanently attached to the rod carrying them, and driven by a cam, or eccentric, on the engine shaft, or by the reciprocating motion of the cross head of the piston, suitably reduced for the required movement of the slides, and the seats being simultaneously adjusted by levers from a common shaft, or by a pinion acting on a rack from each seat or by the action of right and left handed screws or a rod passing through and carrying both seats, as described."

---

24. For a method of *Preventing the Wheels of Locomotives from Sliding* on Railroads; Jordan L. Mott, New York city, August 28. (See specification, vol. ii, 3rd series, p. 348.)

---

25. For an improvement in the *Spring Seats of Riding Saddles;* Thomas Mardock, Liberty, Union county, Indiana, August 28.

The claim in this patent is confined to the peculiar mode of affixing and forming the spiral spring, called by the patentee the "jews-harp spiral spring," and which is made out of a single piece of wire; but the formation of it could not well be understood without drawings, and these we deem it unnecessary to give. In this as in other spring saddles, one end of the spring is attached to the pummel, and the other to the web which is secured to the cantle of the saddle tree. The spring is easily constructed, at little cost, and will, no doubt, operate well.

---

26. For a machine for *Folding and Measuring Cloth;* Joel Spalding, Morristown, La Moille county, Vermont, August 28.

The cloth to be folded by the above named machine, is first wound on to a roller which is placed in bearings in the upper part of the frame, from thence it is brought down to a table, or bed piece, provided with

two hinged retaining bars, one at each end, under which the cloth, as it is folded, is caught and held, alternately at opposite ends. There are two folding boards, one at each end, and which are hinged to pendulous levers. The end of the cloth being secured under one of the retaining bars, the edge of the folding board, on that side, is pressed against it, and pushes it across the table to the other retaining bar, which is lifted up to receive, catch, and retain the cloth, whilst the folding board on the other side performs the same operation. The pendulous levers, to which the folding boards are attached, are so connected together as that whilst one board is folding the cloth the other is being prepared for the returning operation.

Claim.—"I shall claim spreading and folding the cloth upon the surface of the table, or bed piece, in regular layers of equal lengths, as described, by means of the above described arrangement of folding boards, having a reciprocating motion, in combination with the retaining bars, operated by said folding boards, through the intervention of the lifters and levers, the whole being constructed as described."

---

27. For an improvement in the *Mortise* Latch for Doors, Carriages, &c. &c.; Leonard Foster, Boston, Massachusetts, August 26.

The bolt of this latch has a long slot towards its inner end, which fits into the square spindle of the knobs, so that it can slide on it, and its outer end be lifted up by turning the knobs. There is a thumb knob attached to this bolt on its inner side, the shank of which plays loosely in a mortise in that part of the door through which it passes, the lower edge of the said mortise being provided with two or three notches into which the shank of this knob fits. By this arrangement it will be perceived that by lifting the shank of this thumb knob out of one of these notches and pushing it, (together with the bolt,) to the second or third notch, the outer end of the bolt is pushed into the hasp on the jamb of the door, and thus locked. And there being no corresponding knob on the outside it cannot be unlocked, or lifted out of the notch, except by a key, which acts upon it in the usual way; the shank of the small knob and the notches in the mortise answering the purpose of the common tumbler.

Claim.—"What I claim as new in my improved trinity mortise lock, is the manner in which I have arranged and combined the respective parts thereof so as to cause it to answer the triple purpose of a latch, a bolt, and a lock; that is to say, I claim the forming of the latch bolt with a slot, or mortise, through it to admit of its sliding back and forth upon the square shank of the knobs, or handles, whilst it is capable of being raised as a latch by said handles, and this I claim in combination with the arrangement by which the thumb knob is connected with the latch bolt, on the inner side of the door, the shank of which knob is made to operate in an opening substantially like that described; and is so constructed, also, as to be operated on by a key on the outer side of the door, in the manner described; the catch, mortises, and other parts, being likewise arranged and operating substantially in the manner described. I claim, also, the mode of applying the said

latch bolt to sliding doors by modifying the same to adapt it to this purpose."

---

28. For an improvement in the *Caboose, or cooking Stove;* Michael Rocher, city of Nantes, in the kingdom of France, August 28.

The object of this improvement is to adapt the caboose used on board of ships, or other vessels, to the purpose of distilling salt water. The caboose is divided, by a diaphragm, into two compartments, an upper and a lower; the lower one contains the fire chamber and oven, which are surrounded by the salt water chamber, extending all around and over them, and the upper compartment forms a steam chamber, into which the kettles, &c., for cooking extend. A tube rises from the middle of the diaphragm to a considerable height in the steam chamber to convey the steam from the salt water compartment to the steam chamber, from which it is conducted by a pipe to the refrigerator, in which there is nothing peculiar.

Claim.—"What I claim as constituting my invention, and which I desire to secure by letters patent, is the dividing of the caboose, or cooking apparatus, into two compartments, the uppermost of which is to constitute a steam chamber, which is separated from the lower compartment, or boiler, by the diaphragm, or bottom, the two parts being combined with each other and with the condenser, substantially in the manner and for the purpose set forth."

---

29. For a *Self-acting Feeder, for Supplying Steam Boilers;* Ethan Campbell, city of New York, August 28.

In this feeder the supply of water to the boiler is regulated by two floats, one in the boiler and the other in a feeding cylinder, or reservoir. The upper part of the boiler communicates with the upper part of the feeding cylinder by a pipe governed by a valve, connected with the rod of the float in the feeding cylinder, for the purpose of admitting the steam to press on the top of the water therein. The stem of this float is also in connexion with another valve which regulates the admission of water to the feeding cylinder, which is connected with the boiler below the water line, by means of a pipe provided with two lifting, conical valves, one of which is operated by a lever that is attached to the stem of the float in the boiler. When the reservoir has a sufficient supply of water, the float is borne up in it, which keeps the valve in the supply pipe closed, and that in the steam pipe open, thus admitting and equalizing the pressure of the steam on the water in the two vessels. In this condition the apparatus is in readiness to supply water to the boiler when it becomes necessary. When the water in the boiler sinks too low, the float following it, the valve in connexion with this float is opened, and as the other valve in the same pipe opens upwards, the head of water in the reservoir being higher than in the boiler, and the steam pressing equally on both, this valve is opened and the water flows into the boiler until it reaches the level of the water in the reservoir which closes the valves and stops the supply; and the discharge of the water from the reser-

voir causes the float therein to sink, and to close the valve in the steam pipe and open the one in the supplying pipe.

The claim is to the mode of combining the operation of the float in the reservoir, and the valves in the steam and supplying pipes, with the float in the boiler, and the valves in the pipe which conducts the water to the boiler.

---

30. For an apparatus for *Rectifying Spirits;* Augustus V. H. Webb, city of New York, August 28.

Claim.—"I do not claim, as my invention, rectifying spirits, or whiskey, by means of carbonate of potash, chloride of calcium, or any other chemical agent having a strong affinity for water, the same having been already employed for this purpose. But what I claim as my invention, and desire to secure by letters patent, is the manner in which I employ the substances referred to for this purpose, in connexion with the cylinders and reservoirs attached to them; that is to say, I claim rectifying ardent spirits by means of one or more vertical cylinders filled with a substance having a strong affinity for water, through which the liquor is allowed to filter, combined with the reservoirs on which said cylinders rest, provided with separate faucets for letting off the water and alcohol, as described."

---

31. For an improvement in the manner of combining *Elevated Ovens* with Cooking and other Stoves; Samuel B. Spaulding, Brandon, Rutland county, Vermont, August 28.

The patentee says—"In my improved mode of attaching elevated ovens to stoves, the ovens themselves are of the same kind with those in ordinary use, and which are constructed either in an oval, or cylindrical, form. In adapting the elevated ovens to stoves not originally intended to have them appended thereto, I construct what I denominate a connecting pipe, which is of a peculiar form; the lower end of it has an opening of such size as to fit on the collar, or rim, of the stove, to which the stove pipe is ordinarily fitted. The upper end of this connecting pipe, which is to be attached to the lower side of the oven, is widened out so as to embrace two openings which lead from it into the flue that surrounds the elevated oven; through these openings the heated air from the stove passes into said flue at a suitable distance from the centre and ends of the oven to insure the regular diffusion of heat. When the elevated oven is not to be used, and it is desired to carry the heated air directly to the exit pipe, it is made to pass along a flat flue which encircles one half of the oven, the course of the draught being governed by means of suitable dampers. By means of this flat flue the apparatus is rendered peculiarly compact."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the manner herein described of combining the elevated oven with the stove by means of a connecting pipe, constructed and arranged in the manner set forth; that is to say, having an open-

ing at its lower end adapted to the neck, or collar, of the stove, and widening out at its upper end so as to embrace the two openings leading into the oven flue. I also claim, in combination with the foregoing, the flat flue leading from the connecting pipe to the exit pipe, and embracing the outer case of the oven in its passage, said flue being furnished with a valve, or damper, which, in combination with the other valves, or dampers, will govern the passage of the heated air from the stove, or through the flue, at pleasure. The whole apparatus being constructed, combined, and arranged substantially in the manner made known."

Practical & Theoretical Mechanics & Chemistry.

Mr. Mallet's *Processes for the Protection of Iron from Oxidation and Corrosion, and for the Prevention of the Fouling of Ships.*

[continued from page 211.]

2. *The Palladiumizing Process.*

The articles to be protected are to be first cleansed in the same way as in the case of zincing, namely, by means of the double salts of zinc and ammonia, or of manganese and ammonia; and then to be thinly coated over with palladium, applied in the state of an amalgam with mercury.

[The directions given as to this process are meagre, in comparison with those supplied for the other processes; but we are informed that the protection afforded by the palladium is as absolute as that by the zincing, and by no means so costly as to exclude it from economical use.]

3. *The Zoofagous Paint.*

After the iron vessel has been zinced and varnished, in the manner before described, it is done all over (above the varnish, of course,) with a strong bodied thick paint. This is composed of drying linseed-oil, red lead, and sulphate of barytes, (or white lead may be used, but not so advantageously,) and a little turpentine. To every 100 lbs. of these ingredients, when mixed, is to be added 20 lbs., or thereabouts, of oxychloride of copper, and three pounds of a mixture composed of hard yellow soap melted with an equal weight of common rosin, and a little water. The colour originally sold in commerce under the name of "Brunswick green," was an oxychloride of copper; but the present Brunswick green of commerce is a different thing, and will not answer. The oxychloride of copper may be obtained at a cheap rate, by various known methods, which it is unnecessary to detail. When the whole of the hull of the vessel has been done over with the paint, it must be permitted to dry and harden for three or four days, before the ship is floated out of dock. The entire series of operations are now completed; and the hull of an iron ship so treated will, Mr. Mallet assures us, "resist all corrosion from the action of air and fresh or sea water, and not be liable to 'fouling,' by the adhesion of marine animals and plants."

Mr. Mallet adds, that the power of the zoofagous paint to prevent 'fouling' arises from the fact, that the insoluble, or difficultly soluble salts of copper, and of certain other metals, are so noxious to the life of marine, or aquatic, animals and plants, which generally attach themselves to ships' bottoms, that they will not adhere or grow upon a surface so treated. The paint, therefore, is only a vehicle for poisonous matter, for which purpose it is requisite that it should have sufficient adhesion to resist the ship's motion, but still should have a slight degree of solubility in water, so that the poisonous matter may be taken up by the absorbent or capillary vessels of any adhering animal or plant. This latter property is given it by the addition of the resinous soap, the proportion of which should be varied to suit the climate to which the ship is going, more being used in frigid, and less in tropical climates. Mr. Mallet prefers using the oxychloride of copper, and has found it by much the most efficacious; but any insoluble, or difficultly soluble, salt of copper, mercury, arsenic, or antimony, or any combination of these, whether soluble or insoluble, may be substituted for it.

General Observations.

Although Mr. Mallet deems it *advisable* that where new ships are intended to be protected by zincing, the iron should go through the whole of the processes before directed, namely, the cleansing, the coating with the triple alloy, the varnishing, and the final coating with the zoofagous paint, he remarks that they are not all equally essential, and points out how the same effects may be produced, though attended with less favourable circumstances, by the adoption of a part only of these processes:

"For, supposing the plates and ribs of iron were merely coated with the triple alloy of zinc, mercury, and potassium, or sodium, without the addition of the protective varnish and zoofagous paint, it is certain that, on the exposure of this alloy to the action of air and water, the positive metal at the surface would be first acted on, and the surface become shortly covered with a very thin coat of amalgamated zinc, which is known not to be acted upon by fluid menstrua, (except under peculiar conditions which do not exist in the case here supposed,) and does not, as I have found by experiment, gather to itself, when exposed to sea or fresh water, any of that calcareous coating which is productive of the fouling of vessels. The advantage gained by varnishing over this triple alloy coating is of a twofold nature. In the first place, it serves as a mechanical protection to the coating, and thereby to increase its durability; and, secondly, it shields the alloy from contact with the zoofagous paint, some of the ingredients of which would exert an injurious chemical action on the alloy. The office, therefore, of the triple alloy is simply to prevent corrosion and oxidation, (including, where used by itself, that of preventing the formation of calcareous adhesions;) that of the varnish, to protect the triple alloy; and that of the zoofagous paint, to prevent fouling, by the destruction of any marine animals or aquatic plants which may seek to attach themselves to the protected surfaces."

When the addition of the zoofagous paint is not required to prevent fouling, as in the case of articles exposed to the action of the atmosphere only, Mr. Mallet states that any desirable colour may be given to the protecting varnish, by a mixture of colouring materials, but that care must be taken that these colouring materials consist of peroxides not liable to be acted on by air or moisture. The best method to adopt, however, with such articles, is said to be, to pay the varnish all over with a coat of oil paint.

Finally, although the triple alloy is directed in the first instance, to be employed at the fusing temperature, Mr. Mallet states that, by the addition of a larger portion of mercury, articles of cast or of wrought iron or steel may be coated with that alloy at a lower temperature, and even in a cold state, by means of simple contact and friction.

Mech. Mag., Jan. 1842.

On the Existence of Sulphur in Plants.

M. Vogel, Sen., remarks, that it has been proved by the late M. Planche and other chemists, that many plants contain sulphur. Water cresses, *Lepidium sativum*, L., are among those which especially contain much sulphur.

As soils distant from volcanoes do not contain perceptible traces of sulphur, it appears to M. Vogel not impossible that plants, which are much disposed to assimilate sulphur, may have the property of deriving it from the decomposition of the sulphuric acid of sulphates. M. Vogel, however, found that seeds placed in a soil perfectly free from sulphur and sulphates, yielded plants which contained a notable quantity of sulphur.

The soil employed for this experiment consisted of coarsely powdered white glass; it was first strongly heated, but not fused, in a crucible, and being afterwards washed with boiling water, not the slightest trace of any sulphate could be detected.

Seeds of water cresses kept in a moist state were placed in this, and when the plants were several inches in height, they were removed with their roots; after having washed the plants, the white fibrous roots were cut off, and these as well as the plants were dried, and on heating them in a retort, it was found that both of them yielded considerably more sulphur than the seeds contained; the expressed juice of the young plants cultivated in the powdered glass also contained soluble sulphates. The seeds of water cresses, sown in coarsely powdered quartz, flint glass, and very fine silica, obtained from silicated hydrofluoric acid, yielded similar results with respect to sulphur and sulphates, though the plants did not flourish so well in the last as in the two former substances.

To obtain approximative results as to the quantity of sulphur in the water cress seeds and the plants which they yielded, the following experiments were made:—The seed [100 grains?] was heated to redness in a retort, and the gases disengaged were received into a solution of potash; acetate of lead was added to the alkaline liquor as long as precipitation occurred. The precipitate was of a brownish colour,

and consisted of hydrate, carbonate, and sulphuret of lead; the two former were dissolved by dilute nitric acid, and the sulphuret of lead remained, which, after washing and drying, weighed 0.95 gr., which indicated 0.129 gr. of sulphur. According to this experiment, 100 grs. of the seed contained 0.129 gr. of sulphur.

The young plants obtained from the growth of 100 grains of the seed were similarly treated; their weight was 2040 grs.; they yielded by the above described processes 15.1 grs. of sulphuret of lead, equivalent to 2.03 grs. of sulphur: consequently the dried plants contained nearly fifteen times as much sulphur as the 100 grs. of seed which produced them.

Another experiment was made by projecting into a red-hot platina crucible small successive portions of a mixture of powdered cress leaves with nitrate and carbonate of potash. The residue, heated in the crucible and treated with nitric acid, gave a considerable precipitate with chloride of barium, but, on account of the sulphate of potash which the plant contains, the quantity of sulphur cannot be accurately determined by this process, although in general it is preferable to that above described; 100 grs. of the leaves yielded in this way 4.6 grs. of sulphate of barytes, equivalent to 0.624 gr. of sulphur; but the quantity of sulphate of potash is to be deducted from this.

As the growth of the young plants of water cresses took place in a soil devoid of sulphur and sulphates, and in a room which contained no sulphurous vapours, the origin of the sulphur, M. Vogel remarks, is to him a perfect enigma, and at present he confesses that he is unable to give a satisfactory explanation of it.—*Jour. de Pharm. et de Chim.*, Mai 1842.

Lond. & Ed. Philos. Mag., July, 1842.

Velocity of Water through Pipes.—Mr. Rofe's Experiments at the Birmingham Water Works.

The calculations are for the head of water necessary to keep up a given velocity for every 100 feet run of pipe. The tables were two: in the first V represents the table of velocities in feet per minute, and T the constant numbers for those velocities:

V	T
60	8.62
70	11.40
80	14.58
90	17.95
100	21.56
110	25.35
120	29.70
130	34.
140	38.90
150	44.
160	49.50
170	55.66
180	62.13

In the latter, D represents the diameter of the pipes in inches, and t the constant numbers for those diameters:—

D	t
3	
4	.028
5	.053
6	.078
7	.104
8	.134

As an application of these tables, the following problem was proposed; it having been premised that the formula for their use was—

$$\frac{T}{D + t} = H$$

where H represents the height, or head of water. It is required, then, to determine what head of water will be necessary to send water by an engine through 1,500 feet of six inch pipes to an elevation of 80 feet, at a velocity of 180 feet per minute. Now, by the table, we see that the constant number for 180 feet velocity is 62.13, and the constant number to be added to six inches is .078,

$$\text{and } \frac{62.13}{6.078} = 10.22 \text{ inches,}$$

which is the head of water required to keep up the velocity of 180 feet per minute for every 100 feet run; which, being multiplied by 15, (the number of hundred feet through which it has to pass,) gives 153 inches, or 12 feet 9 inches. This, added to 80 feet, will give 92 feet 9 inches as the column of water which the pump must lift.

Lond. Mech. Mag., May, 1842.

Description of the Tanks for Kyanizing the Timber for the permanent Way of the Hull and Selby Railway.

The apparatus consists of two tanks, a reservoir, two force pumps, and a double air pump. The tanks are cylindrical, with flat ends, and are made of wrought iron plates, nearly half an inch in thickness. They are 70 feet in length, and six feet in diameter. At each extremity is a cast iron door, flat on the outside, and concave on the inner side, provided with balance weights for raising and lowering it. Each end is strengthened by five parallel cast iron girders, whose extremities are held by wrought iron straps, riveted on to the circumference of the tanks. Notwithstanding the great strength of these girders, several were broken by the pressure applied during the process. The vessels are lined with felt, upon which is laid a covering of close jointed fir battens, fastened with copper rivets. This precaution is necessary to prevent the mutual deterioration which would arise from the contact of the iron and corrosive sublimate. There was originally only one brass force pump, two inches diameter, and six inches stroke. This being found insufficient, another was added of four inches diameter,

and henceforward a pressure of 100 lbs. per square inch was easily obtained. The air pump is ten inches diameter, and fifteen inches stroke. Its construction is of the ordinary kind. The author gives, in an appendix to the paper, a minute description of the various parts of the apparatus, with the details of their dimensions and weight. The process is simple and rapid; the corrosive sublimate is first mixed with warm water in a trough, in the proportion of one pound of the former to two gallons of the latter; the clear solution is then poured off into the reservoir, where water is added till it is diluted to the proper point, which may be ascertained by a hydrometer. A more perfect test is the action of the solution upon silver, which it turns brown at the requisite degree of saturation. The operations of exhaustion and pressure employ eight men for five hours, the whole process occupying about seven hours, during which time from 17 to 20 loads are kyanized in each tank. It is desirable that the timber should remain stacked for two or three weeks after kyanizing, before it is used. It was found that about three-quarters of a pound of corrosive sublimate sufficed to prepare one load (50 cubic feet) of timber. About 337,000 cubic feet of timber were kyanized, the average expense of which, including part of the first cost of the tanks, was about 5*d.* per cubic foot. The timber was tested after the process, and it was found that the solution had penetrated to the heart of the logs.

Ibid.

Action of Salts on Living Plants.

From the various experiment which M. Vogel, Sen., has made on the action of salts on living plants, he has arrived at the following conclusions:—

1st. That plants with their roots when immersed in a solution of sulphate of copper, totally absorb the salt, convert it into proto-sulphate, and die quickly.

2nd. That acetate of copper produces the same effects, the salt absorbed becoming proto-acetate of copper.

3rd. That plants absorb sulphate of magnesia, nitrate of potash, and iodide of potassium, and die more or less quickly.

4th. That the sulphates of zinc and manganese are absorbed by plants without suffering decomposition, and the plants die.

5th. That plants absorb nitrate of cobalt and nickel, without being able to absorb the whole of them from solution; but they die, and the same effect is produced by emetic tartar.

6th. That the oxalate and tartrate of oxide of chromium and potash are slowly absorbed by plants, and the bichromate of potash much more quickly. The *Datura Stramonium* and *Galega officinalis* absorb the salt of chromium with the greatest rapidity; they become of a yellow colour and die.

7th. That plants absorb nitrate of silver; but they decompose it, and the oxide of silver is reduced to the metallic state.

8th. That plants absorb also, and totally, the protonitrate of mercury from solution, but the salt is decomposed.

9th. That corrosive sublimate is absorbed by plants; some of them decompose it into calomel, and others absorb it without decomposition.

10th. That plants slowly absorb acetate of lead; and it is decomposed by some plants and not by others.

11th. That plants which contain much carbonate of lime, such as the *Chara vulgaris* and the *Stratiotes aloïdes*, do not absorb a salt of copper from solution: the same also occurs with the *Cereus variabilis.*—*Jour. de Pharm. et de Chem.*, Mai 1842.

Lond. & Ed. Philos. Mag., July, 1842.

Method of Distinguishing between weak Solutions of Nitrates and Chlorates. *By* M. Vogel, Jr.

When a few drops of tincture of litmus are added to a solution of nitrate of potash so as to render it blue, and afterwards concentrated sulphuric acid, the tincture is merely reddened by the sulphuric acid, and by the nitric acid set free, but it is not at all decolorated. A solution of chlorate of potash, on the contrary, which has been rendered blue by tincture of litmus, is entirely decolorated by the addition of concentrated sulphuric acid, a result by which the chlorate is effectually distinguished from the nitrate.

This effect is produced with the chlorate when one part is dissolved in sixty-four parts of water, but it ceases with eighty parts of water; but a solution of indigo is decolorated when water contains only $\frac{1}{300}$th of its weight of chlorate of potash.

This method of distinguishing the chlorates from the nitrates, both in very dilute solutions, has besides the advantage of giving certain results, in decolorating the tincture of litmus, even when the chlorates are accompanied with chlorides and other salts.

Tincture of litmus is not decolorated by a very weak solution of nitrate of potash on the addition of sulphuric acid, even when some hundredths of common salt or of other chlorides are present: it is decolorated only when the nitrate of potash is dissolved in a concentrated solution of common salt.—*Ibid.*

Ibid.

Method of Lowering the "Lights" in some particular Engravings executed in the Wood-cut manner.

Sir.—I here submit a new method of lowering the "lights" on the surface of some particular engravings executed in the wood-cut manner, as, for instance, the copper blocks produced by electrography, and those formed by Mr. Woone's stereotype process: the lines of the pictures in both styles being all one height, on account of the design being engraved on a flat, even surface. The metal casts or blocks are first "stopped" out in the darkest tint by the application of a hair pencil dipped in some strong varnish, as that of copal, asphaltum, or seed-lac, the first mentioned being the most preferable; and then attached to and immersed as positive plate in the single-cell voltaic ap-

paratus used in electro-metallurgic experiments, letting it remain until the parts untouched with varnish have been corroded to the requisite depth. It should then be taken out, dried, and the varnish brush applied to those portions which may be considered deep enough, repeating alternately the varnishing and corrosion, until the cut is graduated to your desire. The character of the engraved lines will not be much injured by the electro-etching process, as the corrosion proceeds with evenness and regularity. The more simple application of nitric or other suitable acid, might probably be found efficacous when the design is of a bold or rude character, and strongly lined.

As a mode of lowering blocks of the above description for typographic printing has long been sought for, the insertion of this little hint may be of service to some of the readers of the Mechanics' Magazine. I have the honour to be, your obedient servant,

M. T. BRAZENDALE.

Lond. Mech. Mag., May, 1842.

Number of Furnaces in Great Britain.

We are enabled this week to furnish a tabular statement, showing the number of furnaces in and out of blast in the United Kingdom, with the weekly "make," in most instances taken from data on which no question can arise as to the accuracy of the returns, while in other cases, we have adopted such estimates as appeared to us, from the information derived, to be sufficiently near for the attainment of the object in view—that of presenting to our readers a complete table, wherein the several iron works of the United Kingdom are classified, with the names of the proprietors, and the weekly product, as also the aggregate returns.

The following summary will at once exhibit the present position of the iron trade:—

	No. of furnaces.	In blast.	Av. weekly make.
South Staffordshire, 1st div.	87	54	4200
" 2d div.	48	32	2475
North Staffordshire	18	12	620
Shropshire	36	24	1355
Derbyshire	15	14	577
Yorkshire	30	24	1059
Scotland	91	65	5525
Northumberland	7	2	120
Durham	2	2	120
Forest of Dean	8	3	120
South Wales	162	112	9000
North Wales	21	6	360
Ireland	2	—	—
Total	527	350	25,531

It will be thus seen, that the number of furnaces in the United Kingdom is 527, of which 350 are in blast, and 177 out of blast, the

quantity of pig iron made, or capable of being made, at the present time (by the furnaces in blast,) being 1,327,612 tons per annum, from which, however, we may deduct 20 per cent.—leaving 1,062,090 tons as the actual make. On comparing this statement with an abstract of the quantity of pig iron estimated to have been manufactured in the year 1839, and which is embodied in Mr. David Mushet's work, entitled *Papers on Iron and Steel*, we find the average weekly make at that period to have been as follows:

	Furnaces.	In blast.	Av. weekly make.
South Staffordshire	126	106	6660
North Staffordshire	10	7	350
Shropshire	34	29	1555
Derbyshire	16	14	660
Yorkshire	29	24	1010
Newcastle-on-Tyne	5	5	250
Scotland	54	54	3790
Forest of Dean	8	5	350
South Wales	127	122	8730
North Wales	20	13	650
Total	429	379	24,005

or an annual make of 1,248,260, which is called in Mr. Mushet's work 1,248,781 tons. It will be thus seen, that, comparing the present make with that of the average of 1839, the number of furnaces in that year was 429, of which 379 were in blast; whereas, in February, 1842, the number had increased to 527, of which only 350 were in work, the majority being at a reduced make of 25 per cent.—the aggregate quantity made weekly being, in 1839, 24,005 tons, and in February, 1842, 25,531 tons—there being an increase, in the past two years, of 98 furnaces, equal to an additional make of 407,680 tons per annum (about one-third the average make,) while the number of furnaces in blast in 1839 was greater than those enumerated as being in operation at the present time.

We do not propose entering further into the subject, but having collected that information, which is not only interesting, but valuable, as statistical detail, we leave to our correspondents to furnish such additional particulars as they may possess, having, so far as lies in our power, devoted our attention to the subject.

Mining Jour., March, 1842.

METEOROLOGICAL OBSERVATIONS FOR JULY, 1842.

Moon.	Days.	Therm. Sun Rise.	Therm. 2 P. M.	Barom. Sun Rise.	Barom. 2 P.M.	Wind. Direction.	Wind. Force.	Water Fallen in rain	State of the Weather, and Remarks.	
	1	70°	87°	29.90	29.90	SW.	Moderate	.70	Par. cloudy.	Par. cloudy; shower
	2	72	82	29.96	29.96	W.	do	.26	Par. cloudy.	Par. cloudy; shower.
	3	72	80	30.00	30.00	SW.	Brisk	.15	Cloudy.	Cloudy; shower.
	4	71	82	30.00	29.96	S. SW.	Moderate		Cloudy.	Cloudy.
	5	71	80	29.96	29.96	SW.	do		Cloudy.	Cloudy.
	6	72	71	29 80	29.83	SW.	do	1.92	Cloudy.	Showers.
	7	61	73	30.00	30.05	SE.	do		Cloudy.	Clear.
⊗	8	66	75	30.00	29.95	SE.	do		Cloudy.	Cloudy.
	9	72	76	29.85	29.85	W.	Brisk	1.85	Cloudy.	Shower.
	10	65	72	29.95	30.00	NW.	Moderate		Cloudy.	Cloudy.
	11	63	77	30.00	30.05	E.	do		Clear.	Clear.
	12	62	80	30 05	30.00	E. SE.	do		Cloudy.	Clear.
	13	64	83	29.90	29.90	SE.	do		Fog.	Clear.
☾	14	72	83	29.80	29.80	S.	do		Cloudy.	Partially cloudy.
	15	65	64	29.80	29.80	NE.	do		Cloudy.	Cloudy.
	16	62	66	29.80	29.80	NE.	do	1.90	Rain.	Rain.
	17	63	80	29.77	29.80	N.	do		Clear.	Clear.
	18	68	82	29.78	29.78	E.	do		Lightly cl'dy	Lightly cloudy.
	19	70	86	29.78	29.78	SW.	do		Lightly cl'dy	Clear.
	20	69	82	29.78	29.85	W.	do	.15	Shower.	Partially cloudy.
☉	21	60	78	30.10	30.10	E.	do		Clear.	Clear.
	22	62	78	30.15	30.15	S. SW	do		Clear.	Clear.
	23	70	83	30.15	30.15	SW.	do		Cloudy.	Clear.
	24	72	83	29.93	29.93	SW.	do	.59	Cloudy.	Shower.
	25	66	74	30.05	30.15	W.	do		Clear.	Clear.
	26	63	82	30.10	30.04	W.	do		Cloudy.	Clear.
	27	68	87	29.94	29.94	SW.	do		Clear.	Lightly cloudy.
	28	72	84	29.90	30.00	E.	do	.38	Par. cloudy.	Rain.
	29	72	82	30.00	30.00	SE.	do	.03	Cloudy.	Clear; rain.
☽	30	73	86	29.85	29.80	W.	do		Clear.	Clear.
	31	76	87	29.70	29.70	SW.	Brisk		Par. cloudy.	Cloudy.
		67.87	79.52	29.93	29 93			7.93		

Thermometer. Max. 87.00 on 15th, 27th & 31st. Min. 60.00 on 21st. Mean, 73.695

Barometer. Max. 30.15 on 22d, 23d & 25th. Min. 29.70 on 31st. Mean 29.93

AUGUST, 1842.

	1	54°	68°	29.90	29.95	W.	Moderate		Par. cloudy.	Par. cloudy.
	2	54	72	30.06	30.10	W.	do		Clear.	Clear.
	3	59	76	30.00	30.03	E.	do		Clear.	Flying clouds.
	4	62	70	30.00	30.00	NE.	do		Cloudy.	Cloudy.
	5	68	65	29.80	29.80	NE.	Brisk	.50	Rain.	Drizzle.
⊗	6	60	72	30.00	30.15	SE.	do		Cloudy.	Lightly cloudy.
	7	66	71	30.00	29.90	NE.	do	.25	Rain.	Showery.
	8	67	76	29.90	29.85	SE. SW.	do		Cloudy.	Lightly cloudy.
	9	68	74	29.90	29.93	W.	do		Cloudy.	Cloudy.
	10	68	78	29.88	29.90	NE.	do		Fog.	Cloudy.
	11	68	76	29.90	29.90	W.	do	.23	Rain.	Lightly cloudy.
	12	68	75	29.86	29.86	SE.	do	.05	Cloudy.	Cloudy; rain.
☾	13	67	76	29.85	29.90	E.	do	.07	Par. cloudy.	Rain.
	14	65	80	30.05	30.00	W.	do	.65	Clear.	Clear; shower.
	15	65	79	29.94	29.86	W.	do		Cloudy.	Hazy.
	16	64	80	29.90	30.00	SW.	do		Cloudy.	Hazy.
	17	70	75	29.90	29.90	SE.	do	.35	Cloudy.	Showery.
	18	73	84	29.83	29.80	SW.	do		Clear.	Clear.
☉	19	70	82	29.80	29.90	W.	do		Clear.	Clear.
	20	64	80	29.90	29.95	W.	do		Lightly cl'dy.	Clear.
	21	64	78	30.00	30.05	W.	do		Clear.	Clear.
	22	64	78	30.15	30.20	NE.	do		Clear.	Clear.
	23	63	75	30.20	30.20	E.	do		Clear.	Clear.
	24	66	74	30.10	30.20	E.	do	1.20	Cloudy.	Rain.
	25	72	79	29.83	29.83	SW.	Brisk		Cloudy.	Clear.
	26	73	82	29.83	29.83	SW.	do	.35	Cloudy.	Clear; shower.
	27	74	82	29.83	29.74	SW.	Moderate		Cloudy.	Flying clouds.
☽	28	71	78	29.74	29.65	W.	do		Cloudy.	Cloudy.
	29	71	83	29.65	29.66	W.	do		Clear.	Clear.
	30	64	75	29.70	29.96	E.	do		Clear.	Clear.
	31	60	77	30.10	30.10	SW.	do		Clear.	Clear.
		65.87	76.45	29.92	29.94			3.65		

Thermometer. Maximum 84 on 18th. Minimum 54 on 1st and 2nd. Mean 71.16

Barometer. Max. 30.20 on 22d 23 & 24th. Min. 29.65 on 28th & 29th. Mean 29.93